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IDENTIFIERS	Maryland; *Technology Education

ABSTRACT

The curriculum materials contained in this document were developed through a cooperative effort by educators in the state of Maryland. It was a curriculum project aimed at the meaningful integration of mathematics and science. It is suggested that these materials be used in two significant ways. First, this document can serve as an instructional materials resource collection. An extensive variety of technology topics are covered, with each topic including detailed information sheets identifying the mathematical and scientific principles that could be studied in a technology education activity. Secondly, this document can serve as a materials resource guide. This is accomplished by providing a format and process for the creation of similar classroom instruction materials. Topics included in this document are: (1) abrasive technology; (2) architectural materials under compression load; (3) bending wood; (4) bridge construction; (5) bridge truss; (6) charpy impact testing; (7) concrete strength; (8) copper electroplating; (9) deck construction; (10) dimensional change in wood; (11) hammer; (12) hardening of steel; (13) heat treating metals; (14) house construction; (15) joining with silver solder; (16) miter joints; (17) nailing; (18) roof framing; (19) screwdriver; (20) steel; (21) trusses; and (22) wall insulation and wood burning stoves. Each of the 22 technology topic entries includes the title, resource information, descriptions of the transparencies, science concepts, mathematical concepts, and transparency masters graphically illustrating the topic. A list of additional documents available from the Division of Vocational-Technical Education, Maryland Department of Education is provided. (KR)

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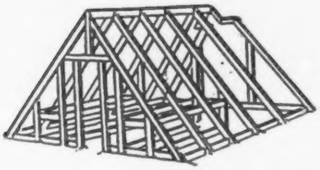
TECHNOLOGY EDUCATION



MATHEMATICS AND SCIENCE INTERFACE CURRICULUM PROJECT

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
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CONSTRUCTION

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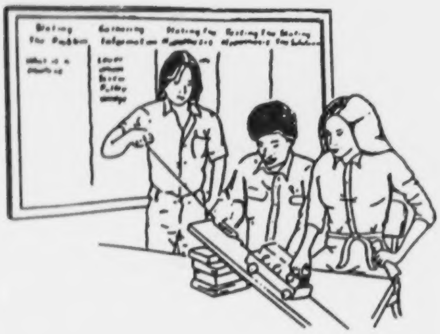
TABLE OF CONTENTS

- CURRICULUM PROJECT STATEMENT
- STATEMENT OF PURPOSE
- WORKSHOP PROCESS
- ACKNOWLEDGEMENTS
- CONTENT INTEGRATION RATIONALE
- DEFINITION OF TECHNOLOGY EDUCATION
- TECHNOLOGY EDUCATION OPPORTUNITIES
- LONG RANGE OUTCOMES
- CLASSROOM USE
- DOCUMENT ORGANIZATION
- POINT OF VIEW
- CONTENT AREA DEFINITION
- TECHNOLOGY TOPICS
- ADDITIONAL DOCUMENTS (BY CONTENT AREA)

MATH, SCIENCE, TECHNOLOGY EDUCATION INTERFACE



A CURRICULUM PROJECT...

Aimed at enriching the content of industrial arts/technology education as well as demonstrating the potential for this area to make a significant contribution to the students' understanding of mathematics and science in the application of such disciplines in the technology education laboratory.

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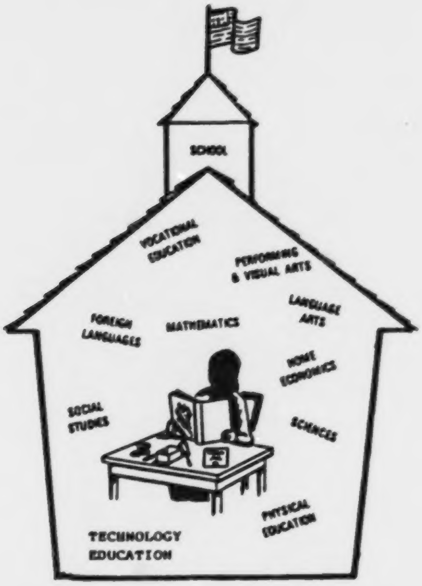
THE PURPOSE...


SCHOOL
VOCATIONAL EDUCATION
PERFORMING & VISUAL ARTS
FOREIGN LANGUAGES
MATHEMATICS
LANGUAGE ARTS
HOME ECONOMICS
SOCIAL STUDIES
SCIENCES
PHYSICAL EDUCATION
TECHNOLOGY EDUCATION

There were four distinct purposes for understanding this project. Each of these have significant value; however, collectively they offer substantial rationale for pursuing holistic learning in our public schools.

They are...

To assist understanding and cooperative relationships in our schools between content areas of mathematics, science and technology education.

To provide for the integration of mathematics and science into the teaching of technology education.

To develop curriculum materials for the integration of mathematics and science into technology education.

To provide inspiration and direction for further content integration for all subjects.

THE PROCESS...

The math/science/technology education project was a cooperative effort by concerned educators in the state of Maryland. It was a curriculum project aimed at enriching the content of technology education through the meaningful integration of mathematics and science. This integration should demonstrate the potential for technology education to make a significant contribution to the students' understanding of these subjects through their application in the technology education laboratory.

The project was conducted over a three year period, beginning in the summer of 1985, continuing in 1986, and concluding in 1987. Each year, teachers from public schools throughout Maryland were assembled for two weeks. The organization was provided by the Department of Industrial, Technological and Occupational Education at the University of Maryland, College Park Campus. During these two week periods, teams of educators were involved in the process of creating technology education instructional materials that integrated the subject areas of mathematics and science. Appropriately, each team represented one school and included one teacher from each of the following areas: Industrial Arts/ Technology Education, Math and Science. It was the responsibility of the technology teacher to lead the team by providing direction for content development. As each technology teacher identified the content from his/her program, the science and math teachers would analyze the content for science and math applications. The outcome of this effort was the creation of appropriate visual masters that would communicate technological content as well as applied science and math principles. This master would be supplemented with information sheets carefully developed by the math/science members of the team. The information sheets would describe in greater detail the specific science and mathematics principles related to the technology content topic.

Follow-up activities involved workshops and in-service sessions in each of the local education agencies participating in the project. Finally, these curriculum materials were prepared for distribution to all participants, as well as local education agencies throughout the state.

ACKNOWLEDGEMENTS...

This document is the result of a major cooperative effort over a three period at all educational levels.

Project Director...	Dr. Donald Maley, Professor Emeritus Department of Industrial, Technological, and Occuaptional Education, University of Maryland, College Park Campus.
Technical Staff...	Anthony Gilberti, Larry Hatch, Charles McLaughlin, Larry Swartzlander, graduate students from the Department of Industrial, Technological, and Occupational Education, University of Maryland, College Park Campus.
Advisory Personnel...	Dr. Charles J. Beatty, Project Director, Technology Education, Maryland on the Move, University of Maryland. Dr. Gerald F. Day, Chief of Special Programs, Maryland State Department of Education, Division of Vocational-Technical Education. Mr. Allan B. Myers, Specialist of Industrial Arts/Technology Education, Maryland State Department of Education, Division of Vocational-Technical Education.
Edited By...	Kenneth L. Smith, Technology Education Teacher, John Hanson Middle School, Charles County Public Schools.

ACKNOWLEDGEMENTS

Teacher Teams...
(1985)

Arbutus Middle School

Technology Teacher	Steve Bartley
Science Teacher	Linda McCelland
Math Teacher	James Hastings

Calvert High School

Technology Teacher	Carl Fenwick
Science Teacher	Terrance Klazer
Math Teacher	Kevin Michael

Catonsville High School

Technology Teacher	Bill Gibbs
Science Teacher	Buddy Brietenbach
Math Teacher	Ken Berry

Cherry Hill Middle School

Technology Teacher	Wilson Thompson
Science Teacher	Gretchen Lawson
Math Teacher	Kermit Williams

Franklin High School

Technology Teacher	Howard Spears
Science Teacher	Stanislaus Ziolkowski
Math Teacher	Joseph Noto

Gaithersburg High School

Technology Teacher	Willie Hill
Science Teacher	Dr. Donald Poe
Math Teacher	Deno Diamonds

Glen Burnie High School

Technology Teacher	Art Chenowith
Science Teacher	John O'Dell
Math Teacher	Glenna Hilditch

ACKNOWLEDGEMENTS

Teacher Teams...
(1985)

John Hanson Middle School

Technology Teacher	Kenneth L. Smith
Science Techer	Christine Smith
Math Teacher	Drew Jepsky

North Carroll High School

Technology Teacher	Stephen Shepler
Science Teacher	Dean Packer
Math Teacher	Babette Leister

Sparrows Point Middle School

Technology Teacher	Will Heilman
Science Teacher	Ruth Jensen
Math Teacher	Paul Leimbach

ACKNOWLEDGEMENTS

Teacher Teams...
(1986)

Einstein High School

Technology Teacher	Robert Wotkowski
Science Teacher	Russell Wright
Math Teacher	Mary Carter

John Hanson Middle School

Technology Teacher	Kenneth L. Smith
Science Teacher	Christine Smith
Math Teacher	Drew Jepsky

Oxon Hill High School

Technology Teacher	Charles Algire
Science Teacher	Michael Mickolay
Math Teacher	Diana B. McCusker

Prince George's County Schools

Frank Grahn
Robert Gray
Connie Jones
George Miles
Roland Moore
Nelson Sharpe

Roosevelt High School

Technology Teacher	Joseph Irizarry
Science Teacher	Bobbie Smith
Math Teacher	Mike Reidy

Springbrook High School

Technology Teacher	David Kaplan
Science Teacher	Paul Kroeger
Math Teacher	Regina Skyles

Wilde Lake High School

Technology Teacher	Charles Venable
Science Teacher	Nicholas Zoulias
Math Teacher	Eric Ebersole

Woodlawn Middle School

Technology Teacher	Richard Harbach
Science Teacher	Cheryl Migliarini
Math Teacher	William Gluth

ACKNOWLEDGEMENTS

Teacher Teams...
(1987)

Chesapeake Middle School

Technology Teacher	Thomas Eoannou
Science Teacher	Donald Stenimler
Math Teacher	Dione McManus

Eastern Vocational-Technical School

Vocational Teacher	Earl Crusse
Science Teacher	William Stacy
Math Teacher	Albert Smith

Earle B. Wood Junior High School

Technology Teacher	Mark Green
Science Teacher	Richard Knight
Math Teacher	Julia Pepeta

Galena Middle School

Technology Teacher	Charles Cooper
Science Teacher	Margaret F. Crow
Math Teacher	Kevin Smith

Merganthaler Vocational-Technical School

Vocational Teacher	Jack Jacobs
Science Teacher	Gail Brayton
Math Teacher	Dwight Evans

North Caroline High School

Technology Teacher	Len Harmon
Science Teacher	Patricia Clay
Math Teacher	Mike Miller

North Carroll Middle School

Technology Teacher	Robert Lenz
Science Teacher	Tim Hontz
Math Teacher	Linda Guillen

ACKNOWLEDGEMENTS

Teacher Teams...
(1987)

Owings Mill High School

Technology Teacher	Roland Phelps
Science Teacher	Sherman Kopelson
Math Teacher	Sharon Oland

Taney Middle School

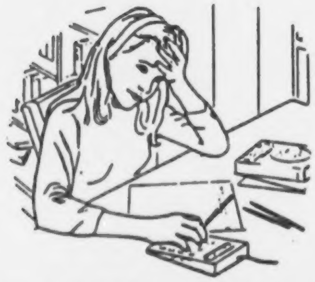
Technology Teacher	Dennis Hearns
Science Teacher	Bruce Guinn
Math Teacher	John Davis

West Frederick Middle School

Technology Teacher	Paul E. Dunford
Science Teacher	Paula Lawton
Math Teacher	Rose Geiger

CONTENT INTEGRATION

A RATIONALE...

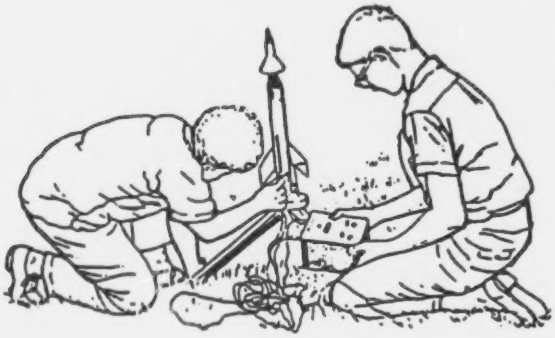


If technology education is to seriously provide for greater understanding and awareness of technological achievement, the issue of holistic learning must be addressed. If one is to truly understand any technological achievement, anthropological or contemporary, a discovery and realization of the specific scientific and mathematical concepts must be accomplished. To illustrate: a student studying rocket technology can use a few tools and machines to build a model of a rocket in any technology education laboratory. However, if that student is to gain a meaningful understanding of rocket propulsion, the scientific and mathematical relationships causing a rocket to function must become part of the instructional activity. Without this effort, the student is involved in a very superficial program.

It is most important to remember that the constructive activity is a vital part of the technology education experience. Generally, constructed items in class serve to motivate students. This motivation can be used to initiate further investigation into a particular curricular topic. Leading a student into a deeper understanding of a "cause and effect" relationship behind a technical device should be a carefully planned and managed instructional process. This process demands the inclusion of science and mathematics; that is, if understanding is the desired outcome.

Technology education offers, within its content and methodology, a prime vehicle through which the subjects of the school can be unified for relevant, meaningful learning on the part of the student. This is particulary true for mathematics and science. Technology education teachers permit students the opportunity to discover through investigation, research and problem solving the "how and why" relationships of science, math and technology education. This approach to subject integration would then continue and enhance the vital "experiential-active" quality that technology education has always valued.

TECHNOLOGY EDUCATION



A DEFINITION...

Technology education is an experienced-based curriculum area in which students study technology... its evolution, utilization and significance. It develops the technological literacy everyone needs. It involves learning experiences, including the application of mathematics and science, in such areas as communications, construction, manufacturing, power and energy, transportation, including the impact of these areas on the environment and society.

TECHNOLOGY EDUCATION

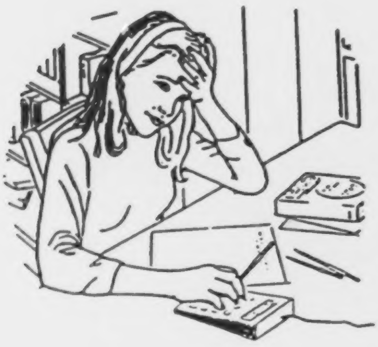
OPPORTUNITIES TO...

Acquire knowledge, understandings and skills needed to function in a technological environment.

Integrate and apply concepts and skills of mathematics, science and communication.

Explore societal and environmental impacts of technology.

Solve problems through laboratory experiences which incorporate creative inquiry, ingenuity, discovery and interaction with technology.



LONG-RANGE OUTCOME...

It is most desirable that this curriculum integration effort will provide direction for not only technology educators, but all concerned educational personnel pursuing meaningful, holistic learning in our public schools. However, as with any curriculum development experience, its usefulness depends on further creation and appropriate implementation by teachers in their classrooms. This body of work has already furnished sufficient guidance for some workshop participants to design and utilize additional materials suitable for use in their particular programs.

It has been convincingly argued that technology education can lead the way for meaningful, relevant subject integration in our schools. The effort in this curriculum project supports that argument. If teachers from the content areas of mathematics, science and technology education can cooperatively discuss, plan, design and produce curriculum materials such as those included in this document, certainly individual schools or local educational agencies should be able to coordinate similar activities. Technology educators should take this opportunity to provide the leadership necessary for further holistic curriculum exploration. Just as leadership and direction was provided by technology educators during this project, continued educational attempts to integrate mathematics and science into the technology education curriculum should be guided by individuals in technology education. The technology laboratories and curricula offer students that place within the school that can bring real understanding to all subjects.

The instructional materials contained in this document serve as examples of successful curriculum integration. The key to this success was carefully managed cooperation among concerned educators. Continued usefulness of these materials will certainly depend on carefully planned and supervised strategies. It is suggested that this document provide the impetus for workshops, seminars and various other in-service activities at all educational levels. The goal... appropriate and meaningful application of mathematics and scientific concepts into technology education.

CLASSROOM USE...

One of the goals of this document is to provide for continued mathematics, science and technology integration. With this in mind, it is suggested that these materials can be used in two significant ways. However, it is important to realize that effective use of this document greatly depends on the initiative of technology teachers, resource teachers and supervisory personnel.

First, this document can serve as an instructional materials resource collection. The teams of educators who participated in the three year workshop have produced an extensive variety of technology topics presented as part of their individual programs. Each topic includes detailed information sheets identifying the mathematical and scientific principles that could be studied in the technology education activity. The quantity and depth of study for these math and science concepts remains at the discretion of the technology teacher. Variations in content usefulness will also depend on individual school or classroom conditions as well as the grade level of students.

Because of the wide range of technology topics presented, many teachers will be able to simply review and select items appropriate for immediate use in the classes. Some will be useful with only minor modifications to subject content. After basic planning and curriculum consideration, most technology teachers should be able to include some of these materials as part of their technology instuction.

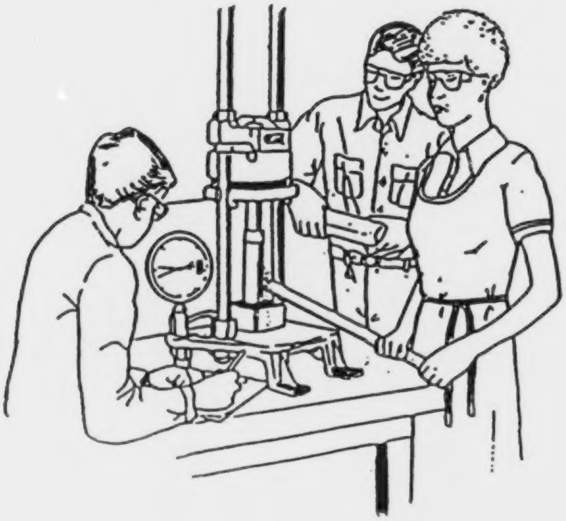
Secondly, this document can serve as a materials resource guide. This is accomplished by providing a format and process for the creation of similar classroom instructional materials. It is suggested that after reviewing these materials and understanding the cooperative 'teaming' process used in their creation, technology teachers will adopt a similar approach as they develop classroom materials appropriate to their programs. Although technology teachers generally possess backgrounds in mathematics and science, it is most valuable to pursue the assistance of the school's mathematics and science personnel in the identification of those principles peculiar to their programs. This effort will insure accurate and relevant subject integration with the technology education curriculum. In addition, math and science teachers could also reinforce technology education concepts in their curricula.

ORGANIZATION...

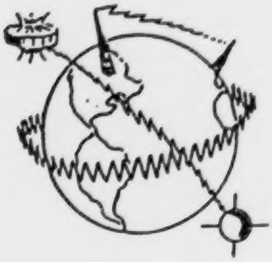
This document is organized into five categories. These categories are selected from the content areas identified in the definition of technology education.

Each technology topic has been placed in the most appropriate content area. However, some topics may be appropriate in more than one area.

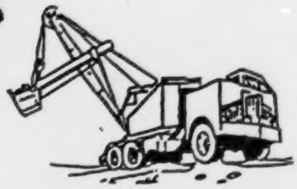
Each content category includes a statement of definition and a point of view.



CONTENT AREAS:

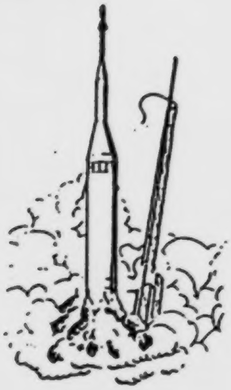


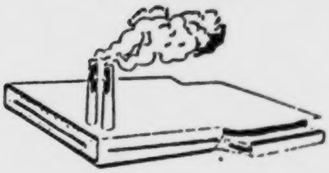
- COMMUNICATIONS



- CONSTRUCTION

- MANUFACTURING
- POWER AND ENERGY
- TRANSPORTATION





CONSTRUCTION

Point of View...

The human creature appears to have a strong inclination to build or construct. Just put some blocks in front of a small child and watch the building begin. The globe is covered with examples of this inclination. Many of these structures are thousands of years old, yet are still standing. The Egyptian Pyramids remain one of the most obvious and well known tributes to this human desire to build. Modern cities throughout the world include structures of all shapes, sizes and architectural styles. There are some who say these structural variations can reveal much about the culture that created them.

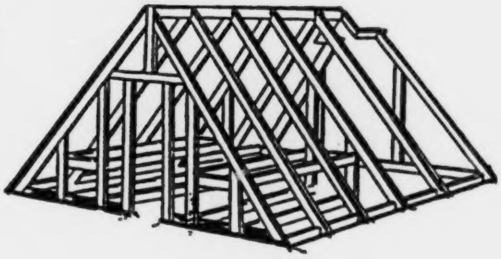
Nearly everyone marvels at tall buildings, beautiful long bridges and strong dams holding back raging, powerful rivers. So many of us use them each day, but still wonder... how did they build that? All these structures exist because engineers and builders have applied basic scientific and mathematical concepts in the use of; tools, machines, materials, energy and processes for building. This application of science and mathematics is the foundation for the creation of the technology needed to solve each particular construction problem.

Every construction problem faced by humanity has been carefully planned. This planning was extensive and required substantial knowledge of physical science and sophisticated mathematics. The Empire State Building, the Pyramids, Golden Gate Bridge, Hoover Dam and Panama Canal, even your home began with this fundamental application of scientific knowledge.

Our future construction needs will present very complex challenges. Taller buildings, longer bridges and efficient, well built homes are just a few. The creation of structures for alternative environments; ocean, underground, undersea, space, including other planets, has already begun. But these challenges are in their infancy. Our success, again, will depend on the intelligent, creative application of science and mathematics to provide the technology required to build it correctly.

CONSTRUCTION

AS A CONTENT AREA IS THE STUDY OF THE ORGANIZATION AND USE OF RESOURCES INCLUDING... TIME, PEOPLE, TOOLS, MACHINES, ENERGY, MATERIALS, DATA AND LAND FOR THE PURPOSE OF ERECTING A STRUCTURE AT A SPECIFIC LOCATION OR ENVIRONMENT.



STRUCTURAL ENVIRONMENTS

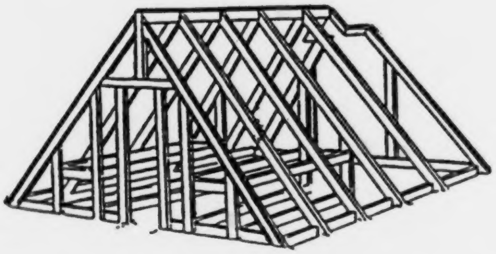
ABOVE GROUND
ABOVE SEA
SPACE

BELOW GROUND
BELOW SEA
OTHER PLANETS

STRUCTURAL TYPES

BUILDINGS
DAMS
TOWERS
ROADS

BRIDGES
CANALS
TUNNELS
SPACE STATIONS



CONSTRUCTION
TECHNOLOGY TOPICS

ABRASIVE TECHNOLOGY

ARCHITECTURAL MATERIALS UNDER COMPRESSION LOAD

BENDING WOOD

BRIDGE CONSTRUCTION

BRIDGE TRUSS

CHARPY IMPACT TESTING

CONCRETE STRENGTH

COPPER ELECTROPLATING

DECK CONSTRUCTION

DIMENSIONAL CHANGE IN WOOD

HAMMER

HARDENING OF STEEL

HEAT TREATING METALS

HOUSE CONSTRUCTION

JOINING WITH SILVER SOLDER

MITER JOINTS

NAILING

ROOF FRAMING

SCREWDRIVER

STEEL

TRUSSES

WALL INSULATION

ADDITIONAL DOCUMENTS

The following documents are also available from the Division of Vocational-Technical Education, Maryland State Department of Education.

POWER & ENERGY

- ANEMOMETER
- AUTOMOTIVE AIR CONDITIONING
  - ACCUMULATOR
  - COMPRESSOR
  - CONDENSER
  - EVAPORATOR
- BASIC ELECTRICAL CIRCUITS
- BATTERY
- BIMETAL DEVICES
- CARBURETOR
- CAPACITORS
- CASTER
- CATALYTIC CONVERTER
- COMBUSTION CYCLE
- COMPUTER COMMAND CONTROL
- CONDUCTORS
- COPPER WIRE RESISTANCE
- DIESEL COMPRESSION RATIOS
- DIODE
- DRY CELL BATTERY
- ELECTROMAGNETIC FIELD STRENGTH... CORE PERMEABILITY
- ELECTROMAGNETIC RELAY
- ELECTROMAGNETS
- ELECTRON BEAM DEFLECTION
- ELECTRONIC MAZE
- FLYBALL GOVERNOR
- FOUR STROKE ENGINE
- FULL WAVE RECTIFICATION
- GEARS
- HALF WAVE RECTIFICATION
- HYDRAULICS
- IMPULSE STEAM TURBINE
- IMPULSE WATER TURBINE
- INCANDESCENT LAMP
- LASER
- LIFT PUMP
- LIGHT EMITTING DIODES
- LOGIC INVERTER
- MAGNETIC COMPASS
- MICROWAVE OVEN
- MOVING COIL AMMETER
- NEWCOMEN STEAM ENGINE
- OHM'S LAW
- OVERSHOT WATER WHEEL
- PARABOLIC FURNACE
- PARALLEL CIRCUITRY
- PASSIVE SOLAR HEATING
- RELATIONSHIP OF VOLTAGE TO BOYLE'S/CHARLES' LAWS
- RESISTORS
- ROCKET ENGINES
- ROCKETRY
- SERIES CIRCUITRY
- SERIES-PARALLEL CIRCUITRY
- SILICON PHOTOVOLTAIC CELL
- SIMPLE MACHINES
- SMOCK WINDMILL
- SOLAR ENERGY
- SOLAR HEATER
- SOLAR WATER HEATER
- TRANSFORMERS
- TRANSISTOR OPERATION
- TURBOCHARGING
- TWO STROKE ENGINE
- WIND TUNNEL
- WIND TURBINE
- WOOD BURNING STOVE

MANUFACTURING

- BANDSAW
- BICYCLE FRAME BRAZING
- BLIND POP RIVETING
- BOARD FOOTAGE
- BUFFING WHEEL
- DESIGN AND CONSTRUCTION-FIBERGLASS BOAT
- DIP MOLDING
- DRILLPRESS
- DRILLS
- ELECTRIC SPOT WELDING
- INJECTION MOLDING
- JIGSAW
- LASER DRILLING-WELDING
- LATHE CUTTING SPEEDS
- MICROMETER
- OXYGEN-ACETYLENE TORCH
- ROTATIONAL MOLDING
- SOLDERING
- THERMOFORMING
- TIN SNIPS
- WOOD FINISHES
- WOOD LAMINATING
- WOOD STAINS
- WOOD TURNING
- WOOD WAXES

COMMUNICATIONS

- BELL'S LIQUID TELEPHONE
- CAMERA
- CRYSTAL RADIO
- DYNAMIC MICROPHONE
- EARLY RADIO
- EARLY TELEVISION
- EDISON'S PHONOGRAPH
- FIBER OPTICS
- HOLOGRAPHY
- LIGHTHOUSE
- PERISCOPE
- PHONOGRAPH
- PHOTO ENLARGER
- PINHOLE CAMERA
- PRINTING PRESS
- PROBLEM SOLVING
- RADAR
- RADIO SYSTEMS
- SATELLITE TELEVISION
- SPEAKER CONSTRUCTION
- SUNDIAL
- TELEGRAPH
- TELEPHONE OPERATION
- TELESCOPE
- TELEVISION CAMERA

TRANSPORTATION

- BELL XP-59A AIRACOMET...FIRST AMERICAN JET
- CANAL LOCK
- CONESTOGA WAGON
- GODDARD'S LIQUID FUEL ROCKET
- HOT AIR BALLOON
- MAGNETIC LEVITATION TRAIN (MAGLEV)
- METRIC DRAGSTER
- OPERATION SAIL
- REACTION ENGINE CAR
- WRIGHT BROTHERS AIRPLANE

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TITLE: Abrasives

DESCRIPTION:

This transparency presents the following concepts related to abrasives:

1. The four basic abrasives and their relative hardness. Flint and garnet being natural minerals, while aluminum oxide and silicon carbide are synthetic.
2. The sizing of the grit as it relates to the degree of roughness of abrasive paper.
3. The basic grid sizes of rough, medium and smooth abrasive paper.

SCIENCE CONCEPTS:

1. Hardness of a material is measured by Moh's Scale using the concept that a harder material will scratch a softer material. Thus, a material like a steel file has a hardness of 6.5 and will scratch anything softer than 6.5. Conversely anything harder than 6.5 will scratch the steel file.

2. Moh's Scale of hardness for minerals (The accepted mineralogy standard.)
    1. Talc
    2. Gypsum
    3. Calcite
    4. Fluorite
    5. Apatite
    6. Orthocase
    7. Quartz
    8. Topaz
    9. Corundum
    10. Diamond

3. This is a commonly used list of easily obtainable materials for testing of hardness.

2.5	fingernail
3.0	penny
5.5	window glass
5.5	knife blade
6.5	steel file

4. Abrasives are chosen for availability, durability, and hardness.

5. Flint is quartz which is silicon dioxide. Quartz is found naturally as a mineral. Flint has a hardness of 7.

6. Garnet is found naturally as several minerals. The mineral pyrope is used in garnet abrasive paper. The grains of this mineral are narrow, wedge-shaped. Garnet has a hardness between 6.5 and 7.5.

7. Aluminum oxide or alumina can be found naturally as the mineral corundum. However, most aluminum oxide used for abrasives is made by purifying the aluminum ore, bauxite, to a crystal form and then adding small amounts of other materials for toughness. The grain shape of this material is a wide wedge. Aluminum oxide has a hardness of 9.

8. Silicon carbide is a product of the electric furnace. Silicon carbide has sharp wedge shapes which are the hardest and sharpest of the synthetic abrasives. It is harder but not as tough and durable as aluminum oxide.

9. Every mineral has a crystal shape that is different from every other mineral. Thus grain shape is dependent on crystal shape.

10.

Abrasive Material	Hardness	Grain Shape	Type
Flint	7		Mineral
Garnet	6.5 - 7.5	Narrow wedge	Mineral
Aluminum Oxide	9	Wide wedge	Synthetic
Silicon Carbide	9 +	Sharp Wedge	Synthetic

TITLE: Abrasives

RELATED VOCABULARY:

1. Abrasive - any hard, sharp material which wears away a softer surface when the two are rubbed together.
2. Aluminum Oxide - aluminum compound made from the ore bauxide.
3. Area - number of units that would cover a plane figure surface.
4. Coarse - rough; made up of fairly large parts.
5. Crystal - the grain of a mineral having a definite shape.
6. Denominator - the numer of parts a whole is divided into.
7. durable - lasting a long time; not soon injured or worn out.
8. fine - not coarse or heavy; very small.
9. flint - a very hard, gray or brown stone that makes a spark when struck.
10. fraction - a division of the whole into parts.
11. garnet - a transparent deep-red mineral.
12. grain size - the size of the particle on abrasive paper.
13. grit - a very fine particle of hard material.
14. linear - of or like a line; a linear measure is a measure of length.
15. medium - that which is in the middle; neither one extreme nor the other.
16. mineral - a natural nonliving material found in the earth.
17. numerator - number above the line in a fraction which shows how many parts are taken.
18. purity - freedom from dirt on mixture; clearness; cleanness.
19. sieve - utensil having holes that let liquids and smaller pieces pass through but not the larger pieces.
20. silicon carbide - a compound of silicon that is manufactured. A very hard material.
21. silicon dioxide - a hard, white or colorless substance. Also known as silica.
22. synthetic - made artifically.
23. tough - strong; hard; difficult.

TITLE: Abrasives

DESCRIPTION:

This transparency presents the following concepts related to abrasives:

1. The four basic abrasives and their relative hardness. Flint and garnet being natural minerals, while aluminum oxide and silicon carbide are synthetic.
2. The sizing of the grit as it relates to the degree of roughness of abrasive paper.
3. The basic grid sizes of rough, medium, and smooth abrasive paper.

MATH CONCEPTS:

1. Fractions -- Division of whole into parts.
   a. Denominator -- identifies # of parts.
   b. Numerator -- identifies # of part being used.

2. Grain size - Size of the grain is named according to the size of the screen opening through which they are sorted. For example, the 60 grit or 60-grain size, would measure about 1/60 of an inch across. The screen would have 60 openings per linear inch.

3. Area -- is the number of square units that would cover the surface of the plane figure. As related to the grain size picture the following sieves used to sort the grit.

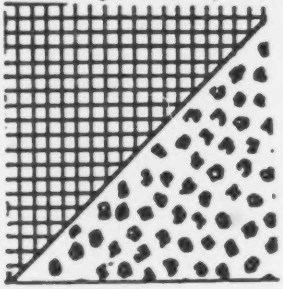


Figure I

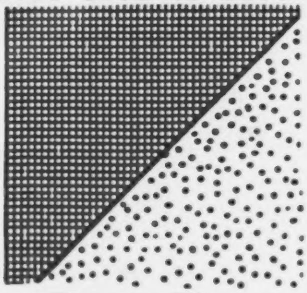
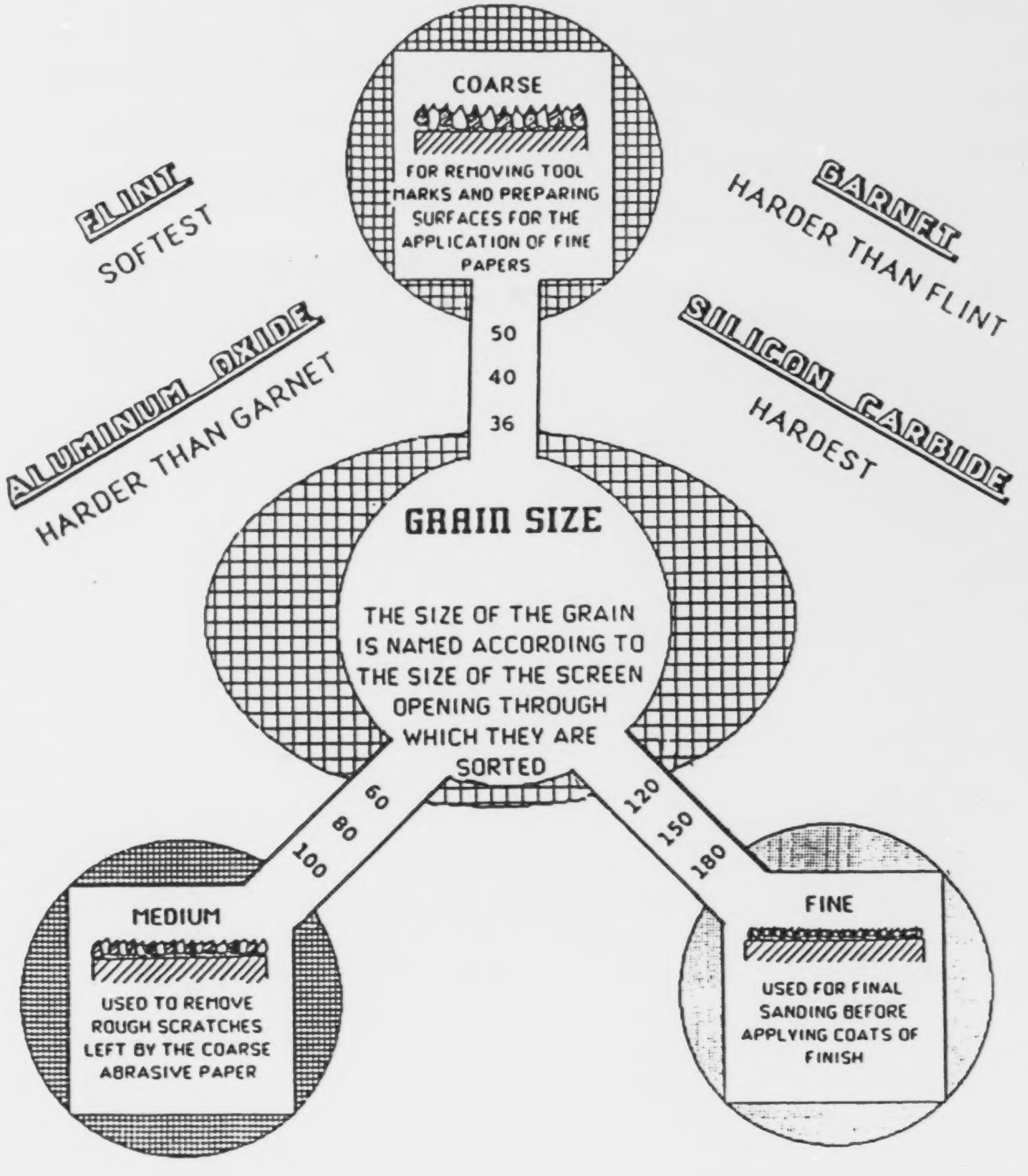


Figure II

Both Fig.I and II have been enlarged 5 times. Figure I represents the screen that would sort out 55-grain size grit. The grid itself is 55 x 55 or 2925 openings make up the screen area. Each opening is 1/55 of an inch which would appropriately sort the grain.

Figure II enlarged 5 times, represents the screen that would sort out 110 - grain size grit. The grid itself is 110 x 110 or 12,100 openings make up the screen area. Each opening is 1/110 of an inch which would appropriately sort the grain.

ABRASIVE TECHNOLOGY



FLINT
SOFTEST

GARNET
HARDER THAN FLINT

ALUMINUM OXIDE
HARDER THAN GARNET

SILICON CARBIDE
HARDEST

COARSE

FOR REMOVING TOOL MARKS AND PREPARING SURFACES FOR THE APPLICATION OF FINE PAPERS

50
40
36

GRAIN SIZE

THE SIZE OF THE GRAIN IS NAMED ACCORDING TO THE SIZE OF THE SCREEN OPENING THROUGH WHICH THEY ARE SORTED

60
80
100

MEDIUM

USED TO REMOVE ROUGH SCRATCHES LEFT BY THE COARSE ABRASIVE PAPER

120
150
180

FINE

USED FOR FINAL SANDING BEFORE APPLYING COATS OF FINISH

TITLE: Architectural Materials in Compression Loading

DESCRIPTION:

The choice of building materials is often based on space available, aesthetic considerations, weight of material, or durability. Architects and designers must know the materials they use and understand that load capacities are a function of the internal, physical and chemical nature inherent in those substances. Three materials commonly used in architecture are: wood, concrete, and steel. These materials present different design solutions due to their range of compression resistance.

Any load can be said to distribute itself uniformly over a material's surface. Thus, capacities are expressed in pounds of loading per square inch of material, (p.s.i.). The reactions of wood, steel, and concrete to stress have been extensively tested and working capacities are well established.

The strength of any material is a function of its internal structure.

SCIENCE CONCEPTS:

1.- Wood is a system of parallel fibers of cellulose whose cell wall thickness adds to its strength.
  - The cellulose fibers are cemented by lignin.
  - Density of wood is determined by the number of annual rings per inch of diameter and, the amount of summerwood in the rings.
  - The compression strength of wood is greatest when loading is parallel to the grain.

2.- Concrete is a composite material that results from the chemical reactions among: - $CaCO_3$ $McCO_3$ (from limestone), alumina and silica, and H_2O.
  - The "cement" above is used to bond various grades of sand and stone to form a solid mass.
  - Stress forces are distributed throughout the material as the cement fills voids between the surfaces of stones and sand grains.

SCIENCE CONCEPTS: (Continued)

3.- Steel - Atoms of carbon and iron form "lattices" which then form crystals of solid steel.

- Stresses are distributed thorughout the bonds of molecules in the lattices.
- The bonds are strong and therefore can divide a stress into infinitely small, easily-handled forces.

DESCRIPTION:

The purpose of this lesson is to calculate the area (of specific architectural materials) needed, given the amount of a working load. The student will need to identify, from engineering tables, the working capacities of wood, concrete, and steel. The student will use the formula: maximum work load = area of material x working capacities, to find the area.

MATH CONCEPTS:

1.- Area of material = length X width.

Example: The area of a 2" X 4" = 8 sq. in.

2. Transposition of Formula:

Original Formula: maximum work load = area of material x working capacities

Transposed Formula: $\text{Area of Material} = \dfrac{\text{maximum work load}}{\text{working capacities}}$

3. Substitution: In our example, the working load = 60,000 lbs. and the working capacities for wood, concrete, and steel are 1,300 p.s.i., 3,000 p.s.i., and 67,000 p.s.i., respectively. To find the area of wood, concrete and steel by substituting the appropriate numbers into the transposed formula.

4. Cancellation of Units: $\dfrac{\text{lbs.}}{\text{p.s.i.}} = \dfrac{\text{lbs.}}{\dfrac{\text{lbs.}}{\text{sq.in.}}} = \dfrac{1}{\dfrac{1}{\text{sq.in.}}} = \text{sq. in.}$

MATH CONCEPTS: (Continued)

5. Division/Approximating: After substituting the appropriate numbers into the transposed formula, you will need to round off or approximate the result. For example, using wood as the material:

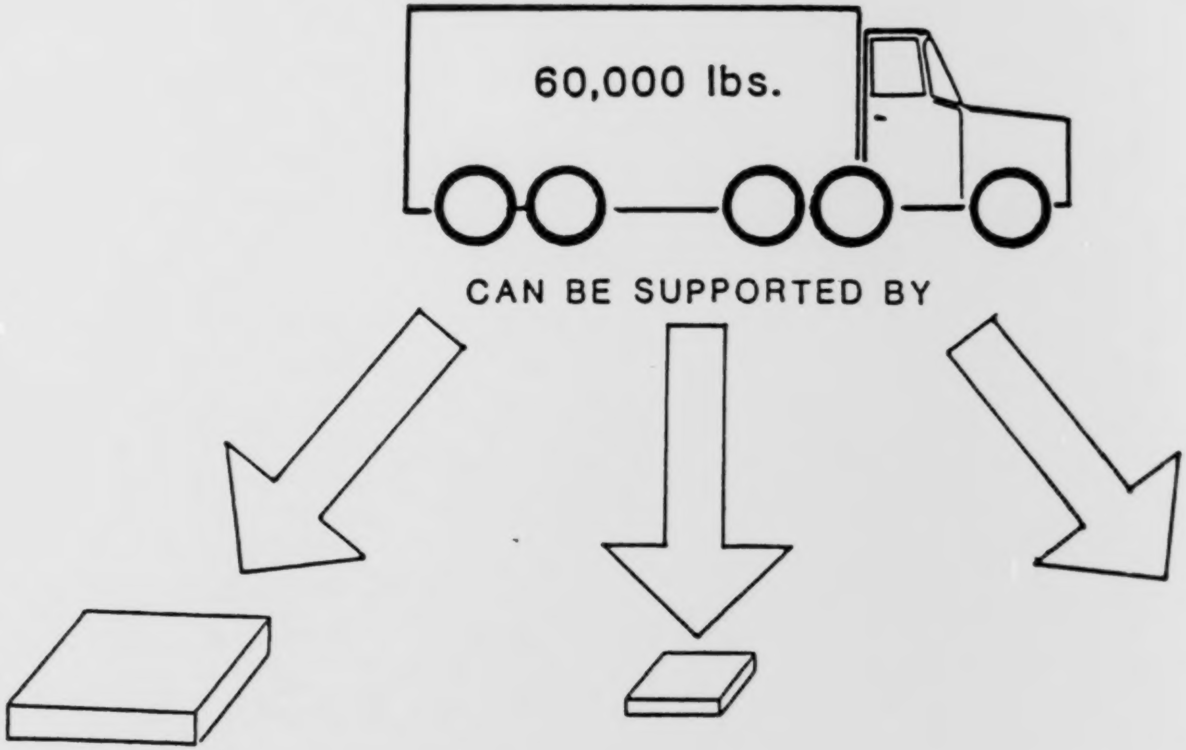
$$\text{Area} = \frac{6{,}000 \doteq 46 \doteq 50}{1{,}3000}$$

6. Ratio: You may want to explain the concept of ratio using Area, Force, and Strength. Set up the ratio: $\frac{\text{Force}}{\text{Strength}} = \text{Area}$

and explain that if force increases and strength remains constant, then area increases. Similarily, if force decreases, and strength remains constant, then area decreases.

ARCHITECTURAL MATERIALS UNDER COMPRESSION LOADING

AREA WILL VARY WITH MATERIAL USED UNDER A GIVEN COMPRESSION LOAD.



60,000 lbs.

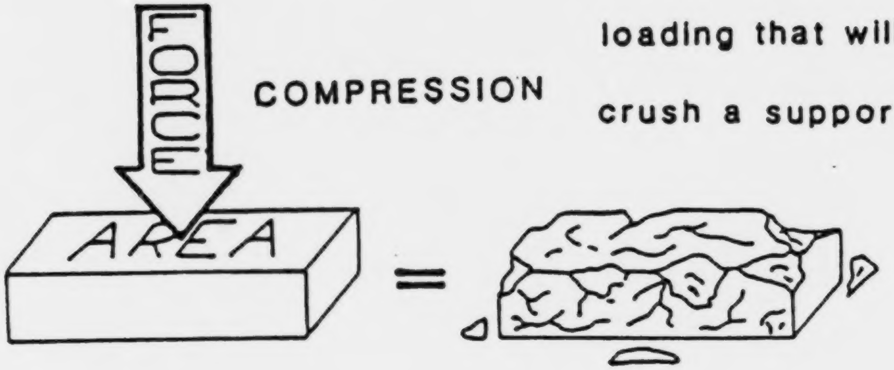
CAN BE SUPPORTED BY

WOOD
50 SQ. IN.

CONCRETE
20 SQ. IN.

STEEL
1 SQ. IN.

ARCHITECTURAL MATERIALS UNDER COMPRESSION LOADING

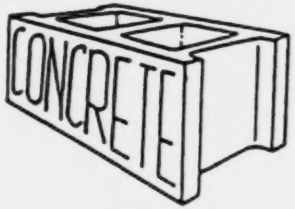


COMPRESSION loading that will attempt to crush a supporting material.

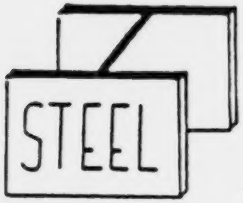
MAX. WORK LOAD = AREA OF MATERIAL x WORKING CAPACITY

WORKING CAPACITIES OF MATERIALS

1,300 p.s.i.



3,000 p.s.i.



67,000 p.s.i.

TITLE: Wood Bending

DISCRIPTION

This transparency illustrates the mathematical and scientific concepts to be considered when bending wood with or with out restraints.

SCIENCE CONCEPTS

1. According to Hooke's Law, F = applied load X L, the amount of distortion is proportional to the distorting force. There is a point (when working with woods) called the elastic limit where once reached, wood when bent will no longer return to its original position. When bending wood we always attempt to go beyond the elastic limit of a particular species of wood. The degree of bending is determined by the thickness, width, length, and mass or load applies to the particular species of wood.

2. Hooke describes two major types of deformability.
   The first type relates only to fluids and does not pertain. The second type is elastic in nature and can be temporary or permanent. Deformability is basically just the amount of distortion or bend proportional to the load applied to the wood.

3. Thermal expansion

   When heated, wood will expand considerably across the grain. Therefore: the width of wood changes dimensions easily where as the length will not. The elasticity of the cell walls also changes allowing the wood to bend more easily according to this concept.

4. As wood dries it's"strength"increases, but the "toughness" and "shock" qualities decrease as you reach fiber saturation point.

5. The cells that make up wood, generally used for woodworking, are called Xylem cells. These cells are found with other cells bundled together. These bundles are called "Vascular bundles". "Vascular" because they transport materials throughout the tree. Xylem in particular transports water molecules generally to the leaves. The water is then used in the photosyntietic process or it is transported out of the tree according to the "Cohesion Tension Theory". Year after year these Xylem cells die and become "wood" and are pushed toward the center of the tree. This is the part of the tree that is actually used in woodworking, and it is here, on the cellular level, where the discussion and understanding start concerning the bending of wood. When this distorting load is great enough to overcome the Cohisive forces caused by the lignin the wood will remain in a deformed state. Lignan is a natural "glue" holding living cells in plants together.

6. ASTM Static bending test (American Society for Testing and Materials). This test measures the resistance of various species of wood in psi.

DESCRIPTION: **Bending Solid Wood**

This transparency illustrates the mathematical and scientific concepts to be considered when bending wood with or without restraints.

MATH CONCEPTS:

1. When wood is bent without restraints, tension and compression are balanced on opposite sides of the neutral axis.

2. When wood is bent with restraints, the neutral axis shifts toward the restraint and the wood undergoes greater compression strain.

3. The ratio of the radius of the bend to the thickness of the stock determines whether or not a restraint will be needed. The better bending species can be free - bent to a radius of 12 inches to 15 inches; Usin a restraining strap, bends to a 2 inch radius or less can be achieved.

4. The bending strength of a piece of lumber is found by applying a load to a horizontal beam and measuring the deflection. Deflection is proportional to the amount of the load until the proportional limit is reached. Then deflection increases faster than the load.

5. Direct variation $a = kb$ and Indirect variation $a = \frac{k}{b}$ where k is a constant.

6. The load bearing capacity varies:
   A. Indirectly with the length (double the length, cut load bearing capacity in half).
   B. Directly as the allowable fiber stress (choose a lumber grade twice as strong, the beam will carry twice as much).
   C. Directly as the width (make the beam twice as wide, it will carry twice as much). .
   D. Directly as the square of the depth (double the depth and it will) carry four times as much).

7. The deflection of the beam varies:
   - A. Directly as the load (double the load, it deflects twice as much).
   - B. Indirectly as the width (use beams side by side the deflection will only be half as much).
   - C. Indirectly as the modulus of elasticity(E) (double E, deflection will be half as much).
   - D. Directly as the cube of the span (double the span, the beam will deflect eight times as much).
   - E. Indirectly as the cube of the depth (double the depth, reduces the deflection to one-eighth).

8. Stress is defined as force divided by area. (Stress = $\frac{F}{A}$). Force may be parallel or perpendicular to the grain.

9. Strain is defined as $\frac{\text{the elongation or distortion of an object}}{\text{the original length of the object}}$.

   (Strain = $\frac{\Delta L}{L}$)

10. Chart and graph reading skills are necessary.

11. Elasticity (modulus of elasticity) is $\frac{\text{stress}}{\text{strain}}$. (E = $\frac{\text{stress}}{\text{strain}}$)
    In steam bending the elastic limit is lowered by heating in order to produce a permanent set. A general rule of thumb is " one hour of steaming for an inch of thickness of air dried wood, one half - hour per inch of green wood." Adjust that rule to the circumstance at hand. Avoid excess steam. Strength losses should be no more than 10% to 20%.

12. The American Society for Testing and Materials (ASTM) has adopted standarized tests for wood strengths. Wood is anisotropic so each stress will be resisted differently. ASTM standards define the physical dimensions of the tests pieces and specify conditions of moisture content, grain direction, growth ring orientation and how free the piece is from defects. Tests results are recorded in a table.

13. The flexure formula states: $\sigma = 1.5\frac{Pl}{bd^2}$
    where σ = bending stress at midspan, upper and lower surfaces of beam (psi); P = load of beam(lb) = span of beam(in.); b = width of beam(in.); d = depth of beam(in.).

14. The modulus of rupture (MR) uses the maximum load in the flexure formula.

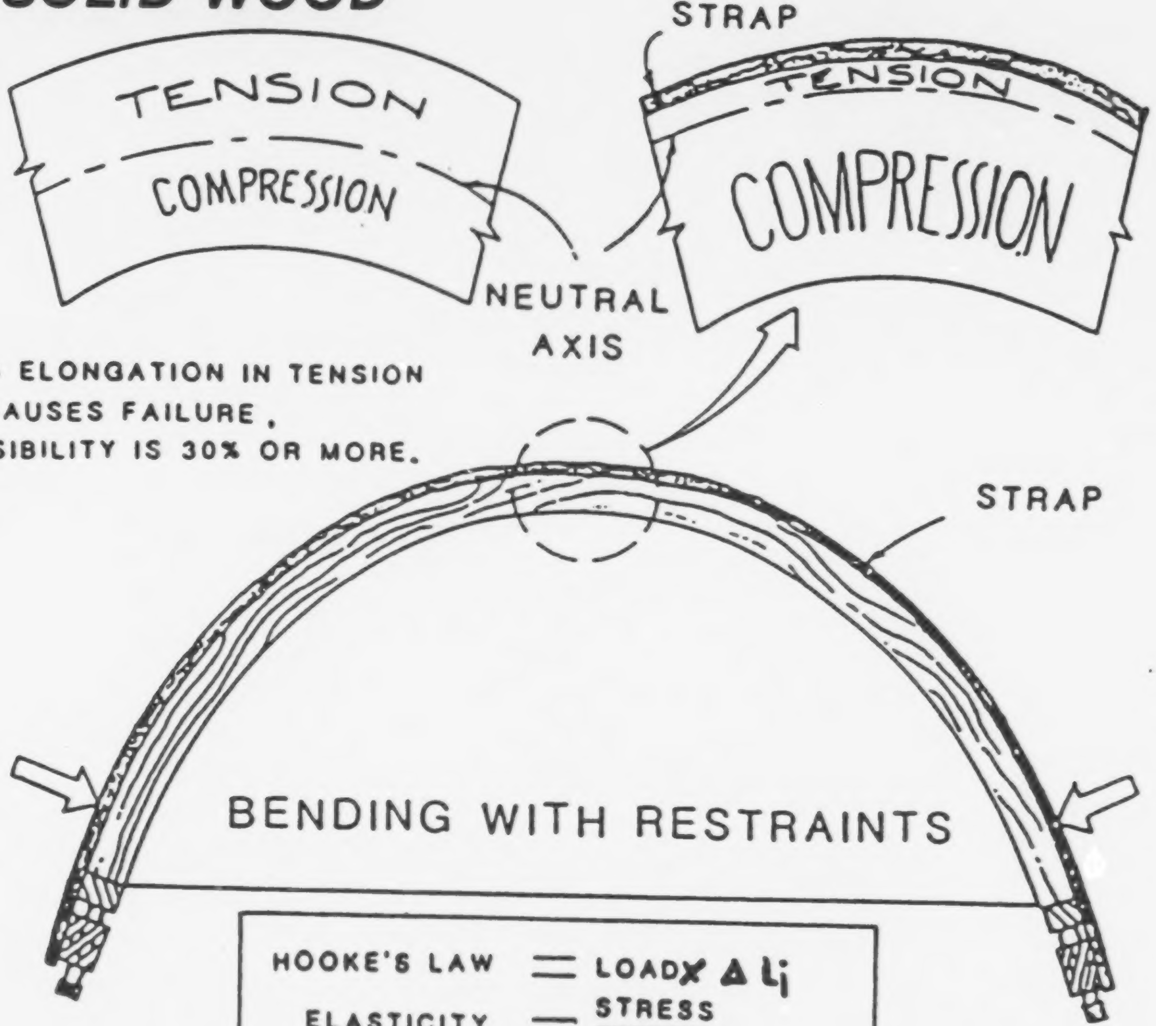
15. The fiber stress at proportional limit (FSPL) uses the proportional limit load in the flexure formula.

16. Solving algebraic formulas given values for various variables.

17. Scientific Notation - Information in the charts may be given in scientific notation where each number is represented as a number between one and ten times a power of ten.

18. Squaring, cubing and finding various powers of numbers (or the reciprocals).

BENDING SOLID WOOD


STRAP
TENSION
COMPRESSION
TENSION
COMPRESSION
NEUTRAL AXIS
STRAP
FORCE

APPROX. 2% ELONGATION IN TENSION CAUSES FAILURE.
COMPRESSIBILITY IS 30% OR MORE.

BENDING WITH RESTRAINTS

HOOKE'S LAW $= \text{LOAD} \times \Delta l_i$

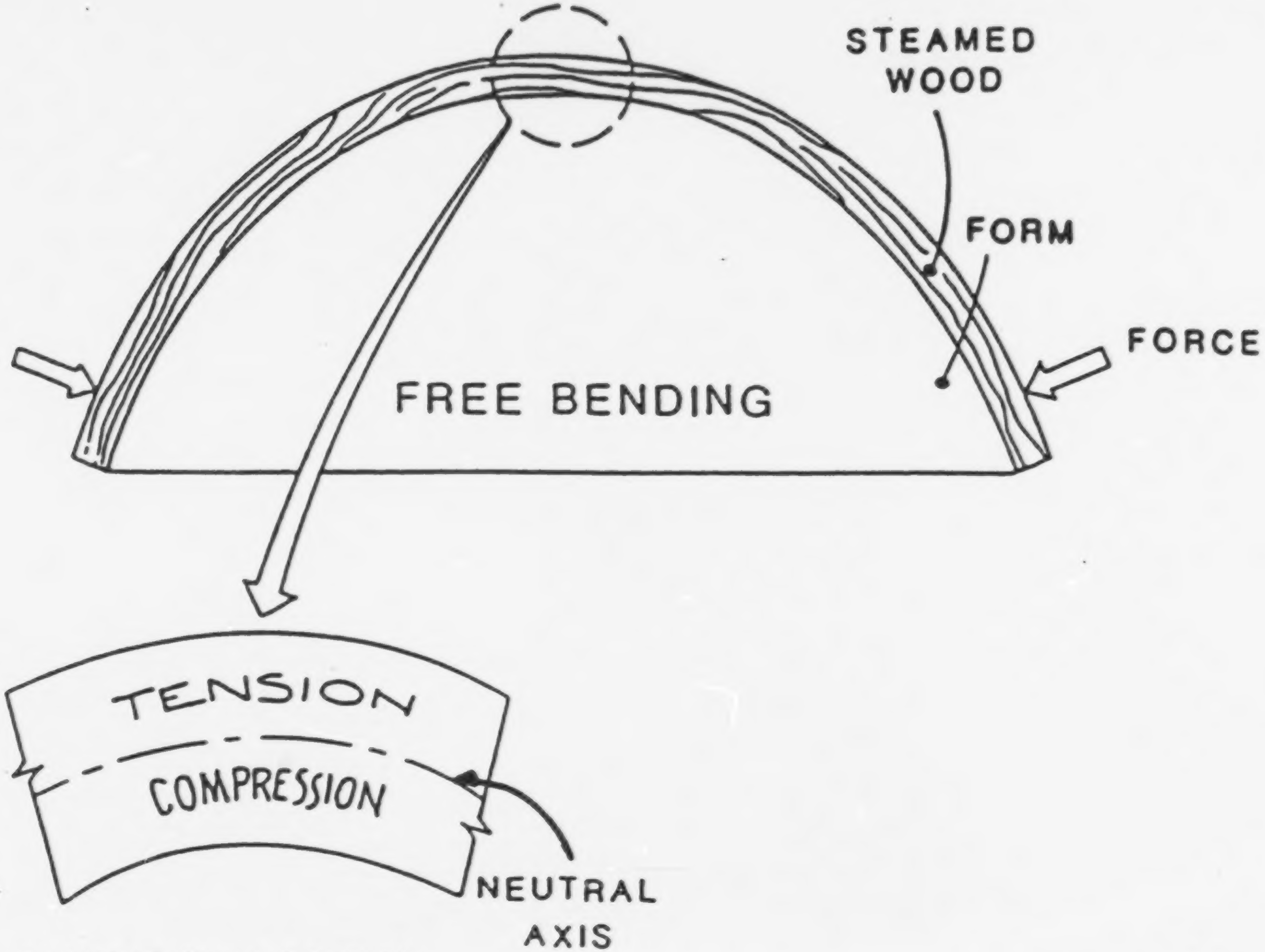
ELASTICITY $= \frac{\text{STRESS}}{\text{STRAIN}}$

STRESS $= \frac{\text{FORCE}}{\text{AREA}}$

STRAIN $= \frac{\Delta\ \text{LENGTH}}{\text{LENGTH}}$

BENDING SOLID WOOD

(Shifting the neutral axis)



STEAMED WOOD

FORM

FORCE

FREE BENDING

TENSION

COMPRESSION

NEUTRAL AXIS

APPROX. 2% ELONGATION IN TENSION CAUSES FAILURE.

TITLE: Bridge Construction and Design

DESCRIPTION:

The weight capacity of a structure is limited to the interaction of external forces exerted upon the internal of the structure itself. This same concept applies to bridge construction. The design (re:geometric) of the construction medium combined with the physical properties of the same medium determines the amount of force which may be supported by the structure.

SCIENTIFIC CONCEPTS:

1. A force is any influence that can produce a change in the linear momentum of a body. The net force acting upon a body is equal to the rate of change of the body's linear momentum.

2. All forces that act upon a system of particles (or points) may be divided into two catagories:
   a.) internal forces - that the particles(or points) within the system exert upon one another.

   b.) external forces - that originale outside the system. These can be:
   (I) Static forces (loads) ex: tensile, shear and compressive forces.

   (II) Dynamic forces - ex: force of impact, vibration, and alternating of cyclic forces.

$$\text{Stress} = \boxed{\text{Force}/\text{Area}}$$

. . . units are the same as that for pressure or pascul

3. Weight is a Force

Where:

$$\boxed{F = MA}$$

F = Force
M = Mass
A = Acceleration
(here a=g= $9.8m/S^2$)

For a bridge:

$$\boxed{W = MG}$$

W = Weight
M = Mass
G = $9.8m/S^2$ (acceleration due to gravity)

. . . weight is a force

TITLE: Bridge Construction and Design

DESCRIPTION: The weight capacity of a structure is limited to the interaction of the external forces exerted upon the internal forces of the structure itself. The same concept applies to bridge construction. The design of the construction medium combined with the physical properties of the same medium determines the amount of force which may be supported by the structure.

MATH CONCEPTS:

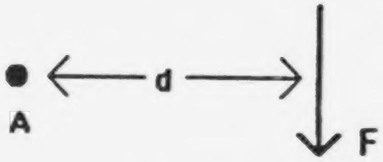
1. Surface Area = Length x Width (measured in square units)

2. Vector: Graphic representation of magnitude and direction of a force.

3. Resultant Vector (Vector addition): The sum of two vectors is equal to the sum of the individual components.

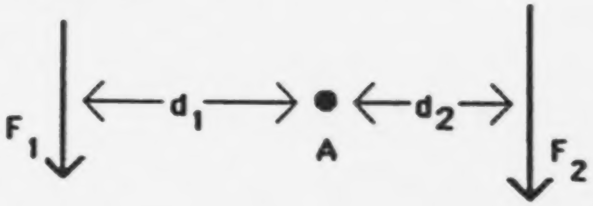
   Example: $V1 = (a,b)$ & $V2 = (c,d)$ then $V1+V2 = (a+c,b+d)$.

4. Moment (Torque): Something producing or tending to produce rotation or torsion. A moment is the result of some force acting at a perpendicular distance from a pivot point.



$$M_A = F \times d$$

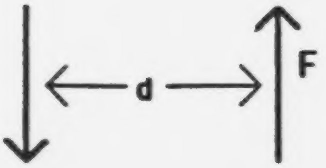
5. Opposing Forces: Forces acting on the same point in different directions.



$$M_A = (F_1 \times d_1) - (F_2 \times d_2)$$

6. Mechanical Couple: Consists of two forces which are:

   i. equal
   ii. acting in opposite directions
   iii. separated by some perpendicular distance (d).



Couple Moment = F x d

BRIDGE DESIGN
&
CONSTRUCTION

FORCE
(internal forces)
(external forces)
WEIGHT
-STRESS

GEOMETRIC MEASURE
(angles & areas)
VECTOR ANALYSIS
(magnitude & direction)
MOMENTS (TORQUE)

TITLE: BRIDGE TRUSS

CATEGORY: CONSTRUCTION

DESCRIPTION:

A truss is a framed structure consisting of a group of triangles arranged in a single plane. Trusses are used in construction to provide strength, reduce weight, and conserve materials. A truss modifies forces in ways which make the structure more efficient.

SCIENCE CONCEPTS:

1. A force is any push or pull.
2. The effect of force either changes the shape or motion of a body or prevents other forces from making such changes.
3. Every force produces a stress in the part on which it is applied.
4. There are four kinds of forces: tension, compression, torque, and shear.
5. Compression and tension forces are involved in the construction of a bridge.
6. A compressional force shortens or squeezes the object.
7. A tension force stretches the object.
8. Forces may act together or be matched by another single force.
9. Forces exist not singly, but always in pairs, equal and opposite.
10. When two objects are in contact, equal and opposite forces are produced at the contacting surfaces.
11. The center of gravity is the point at which an object is statistically balanced.
12. A mechanism is stable/balanced when the center of gravity falls within its base.
13. A mechanism becomes unstable when the center of the gravity falls outside its base.

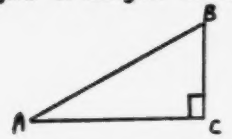
TITLE: BRIDGE TRUSS

CATEGORY: CONSTRUCTION

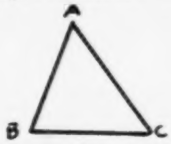
MATHEMATICAL CONCEPTS:

1. Types of triangles used in the construction of trusses:

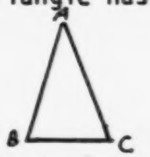
   A right triangle contains a right angle.



   An equilateral triangle has three equal sides.



   An isosceles triangle has two equal sides.



2. To find the amount of pressure which can be applied, you have to know the total force and the areas it is spread over.

3. To calculate the area:

   $\text{Area}=\frac{\text{Force}}{\text{Pressure}}$; $A=\frac{F}{P}$; $A=\frac{40}{10}$; $A=4$

4. To calculate the force:

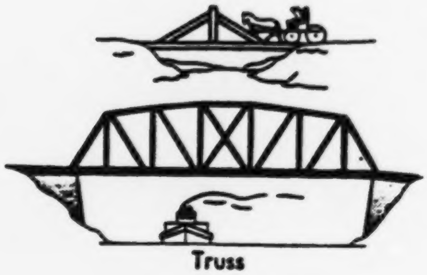
   Force=Pressure x Area; F=P x A; 2 gm x 20 cm^2; F=40 gr. per sq. cm.

5. To calculate the amount of pressure being exerted:

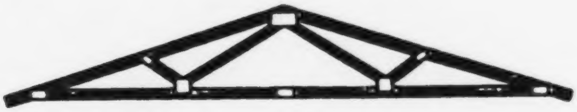
   $\text{Pressure}=\frac{\text{Force}}{\text{Area}}$; $P=\frac{F}{A}$; $P=\frac{1{,}000\text{ gr.}}{100\text{ cm.}}$; P=10 gr. per sq. cm.

TRUSSES

A truss is a framed structure consisting of a group of triangles arranged in a single plane.

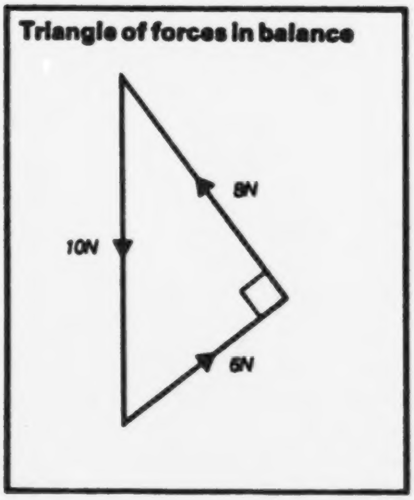


Trusses are used in construction to provide strength and reduce weight.



A truss modifies forces.

Forces are actions that change the shape of the body on which they act.


Triangle of forces in balance

$$\text{RESULTANT FORCE} = \sqrt{X^2 + Y^2}$$

$$= \sqrt{6^2 + 8^2}$$

$$= \sqrt{36 + 64}$$

$$= \sqrt{100}$$

$$= 10$$

TITLE: CHARPY IMPACT TESTING

CATEGORY: RESEARCH AND EXPERIMENTATION

DESCRIPTION:

Impact testing provides for testing materials under conditions of shock loading at fixed temperatures. The Charpy test is most revealing for disclosing low temperature brittleness in otherwise ductile metals.

SCIENCE CONCEPTS:

1. Impact is the action of two bodies in collision whereby the velocity of one or both bodies is changed.
2. Velocity is the speed and direction of a moving object. Sometimes velocity is described as angular velocity which is the number of degrees a rotating or revolving object turns in one second.
3. Energy is the capacity for doing work.
4. Potential energy is energy a body possesses by virtue of its location or configuration.
5. Kinetic energy is energy a body possesses due to its motion.
6. Ductility is a property of a substance that allows it to be pulled out into thin threads or wires without breaking. It is a property of many metals including copper and aluminum.
7. Brittleness is the property of a material that causes it to fracture under slight bending or deforming. Brittleness is characteristic of some alloys of steel.
8. To anneal is to heat or cool slowly. In many cases metals and glass become less brittle.
9. Momentum is the product of an objects mass and velocity. It is also described as a measurement of a moving objects tendency to keep moving.
10. A pendulum is a body suspended from a fixed point so as to swing back and forth by the interaction of gravity and momentum.
11. Gravity is the force that attracts all bodies toward the center of the earth.

TITLE: CHARPY IMPACT TESTING

CATEGORY: RESEARCH AND EXPERIMENTATION

MATHEMATICAL CONCEPTS:

1. The impact testing machine allows the measure of the angle through which the pendulum swings and the calculation of the energy consumed in breaking the specimen.

2. Velocity

   $v_{av} = \frac{s}{t}$

   v_{av} = average velocity
   s = displacement
   t = elapsed time

3. Kinetic energy

   K.E. = $\frac{1}{2}mv^2$
   or
   K.E. = $\frac{1wv^2}{2g}$

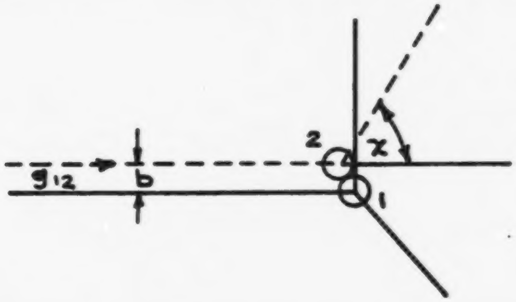
   K.E. = kinetic energy
   m = mass
   v = velocity
   w = weight
   g = acceleration of gravity

4. Potential energy

   P.E. = mgh
   or
   P.E. = wh

   P.E. = potential energy
   m = mass
   g = acceleration of gravity
   h = vertical distance
   w = weight

5. Impact parameter. Collision between 2 hard spheres. The trajectory of sphere 2 in the coordinate system in which sphere 1 is stationary is indicated by the broken line. "χ" is the angle of deflection.

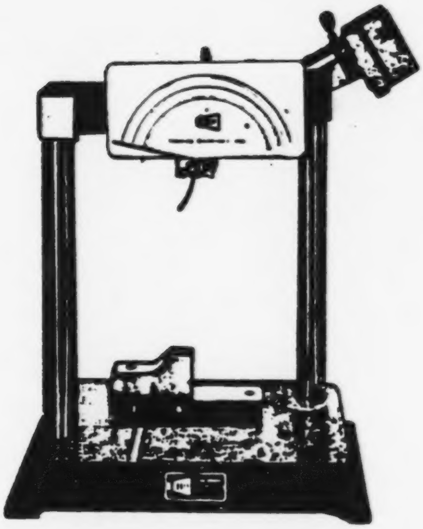


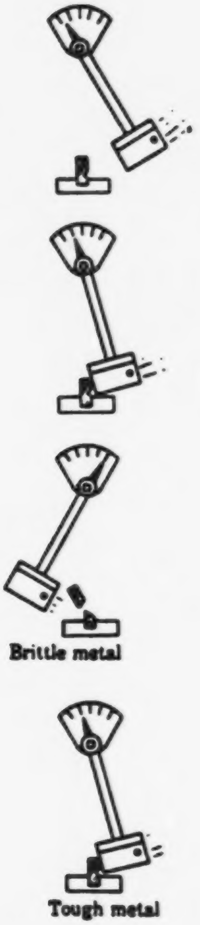
6. Impact coefficient (coefficient of restitution) is the ratio between the difference of velocities of the two bodies after impact to the same differences before impact. The range of values is from unity (1) for impact of perfectly elastic bodies to zero (0) for fully inelastic bodies.

7. Energy lost = $\frac{M_1 M_2 (1 - f^2)(v_1 - v_2)^2}{2(M_1 + M_2)}$

   M_1 and M_2 = masses of 2 bodies
   v_1 and v_2 = velocity of the 2 bodies, respectively
   f = impact coefficient

CHARPY IMPACT TEST




Brittle metal
Tough metal

MATH CONCEPTS

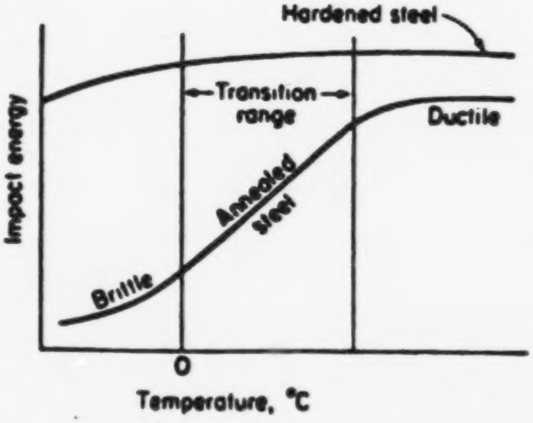
MEASUREMENT OF ANGLES

CALCULATION OF ENERGY CONSUMED

VELOCITY

KINETIC AND POTENTIAL ENERGY

GRAPHING RELATIONSHIPS



SCIENCE CONCEPTS

IMPACT

ANNEALING

DUCTILITY

BRITTLENESS

PENDULUM

TITLE: AGGREGATE SIZE AND HEAT OF HYDRATION IN RELATION TO STRENGTH OF CONCRETE

CATEGORY: RESEARCH AND EXPERIMENTATION

DESCRIPTION:

A study of the strength of concrete in relation to aggregate size and heat of hydration will be conducted. The hypothesis is that there is a relationship between aggregate size and heat of hydration. The larger aggregate size will be a high heat absorber of the heat of hydration and a low dissipator of the heat of hydration.

The heat of hydration from the exothermic reaction of cement and water will be measured by a thermocouple. These factors will then be further tested in relation to the strength of the concrete formed.

SCIENCE CONCEPTS:

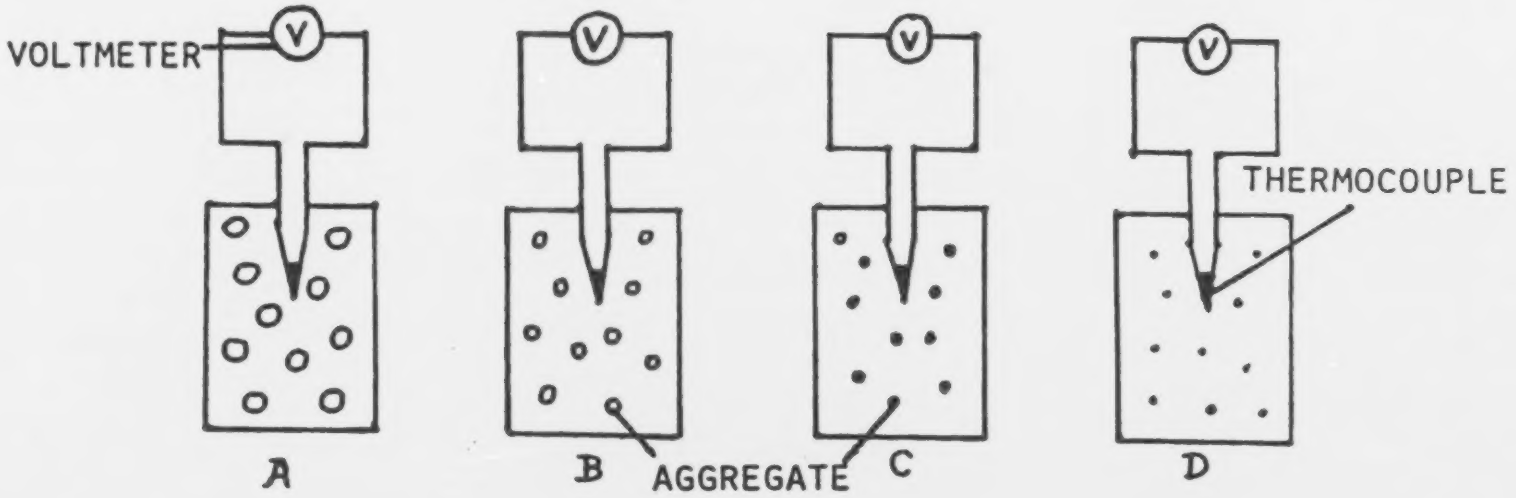
1. Concrete is formed by mixing cement (lime, silica, alumina, and iron components), fine aggregate (sand), coarse aggregate (pebbles), water and air.
2. The chemical reaction of cement and water, called hydration, makes concrete. This reaction depends on temperature and moisture conditions.
3. The hydration reaction is an exothermic (heat-releasing) reaction.
4. A thermocouple converts heat energy into electrical energy. This energy can be measured with a voltmeter.
5. The size of the aggregate used to make the concrete will affect the rate at which the exothermic reaction occurs. This in turn will affect the strength of the concrete.
6. The strength of the concrete samples made with varying aggregate sizes can be tested using a compression strength tester.

MATHEMATICAL CONCEPTS:

1. The relationship between the strength of the concrete, as determined by the compression test, and the exothermic reaction rate, as measured by the thermocouple and voltmeter, can be correlated to the aggregate size used in the concrete samples.
2. Comparative graph analysis.
3. Equations of hydration:

$$2C_3S + 6\ H_2O \text{ ———— } 3\ CaO \text{ x } 2\ SiO_2 \text{ x } 3\ H\ O + 3\ Ca\ (OH)_2$$
$$2C_2S + 4\ H_2O \text{ ———— } 3\ CaO \text{ x } 2 \cdot SiO_2 \text{ x } 3\ H\ O + Ca\ (OH)_2$$

AGGREGATE SIZE AND HEAT OF HYDRATION RELATIVE TO CONCRETE STRENGTH


VOLTMETER
V
V
V
V
THERMOCOUPLE
A
B
AGGREGATE
C
D

CONCRETE SAMPLES

Title: Copper Electroplating

Category: Processes

Description:

Electroplating deposits a layer of a metal such as copper on a base metal such as steel. A part to be electroplated is placed in a tank containing an electrolyte. In copper electroplating, the anode is connected to a piece of pure copper, the cathode is connected to the part, and the electrolyte is a copper sulfate ($CuSO_4$), a salt containing copper. When direct current is applied to the leads ,particles of copper leave the anode and enter the electrolyte, causing the solution to have too many copper ions. The excess copper particles are attracted to the part to be plated. The current remains on until the proper coating thickness is obtained.

Title: Copper Electroplating

Category: Processes

Science Concepts:

1. Electroplating uses the motion of ions in a liquid to deposit a layer of one type of metal on another.
2. An electrolyte is a liquid that carries a current.
3. Ions are atoms that have gained or lost electrons, and therefore have a positive or negative charge.
4. Electrodes are the positive or negative terminals of electrical devices.
5. The cathode is the negative electrode.
6. The anode is the positive electrode.
7. Electricity is a flow of electrons.
8. Conductors are materials with little or no resistance to a flow of electrons.
9. An atom is the smallest unit of an element having the properties of that element.
10. Protons are particles in atoms having a positive charge.
11. Electrons are particles in atoms having a negative charge.
12. Direct durrent (dc) is electrical current that does not change direction.
13. A coulomb is a unit describing one ampere of current flow per second.
14. Amperes are the standard unit of current, equal to about 6.24×10^{12} electrons passing a given point each second.
15. Valence electrons are found in orbits on the outer periphery of the atom, and are not as strongly attracted to the nucleus of the atoms on the innershell. The valence electrons of metals move freely, and therefore metals are good conductors.

Title: Copper Electroplating

Category: Processes

Math Concepts:

1. $V = \pi r^2 h$ Volume (of cylinder) = Pl x RADIUS ^{2}x height

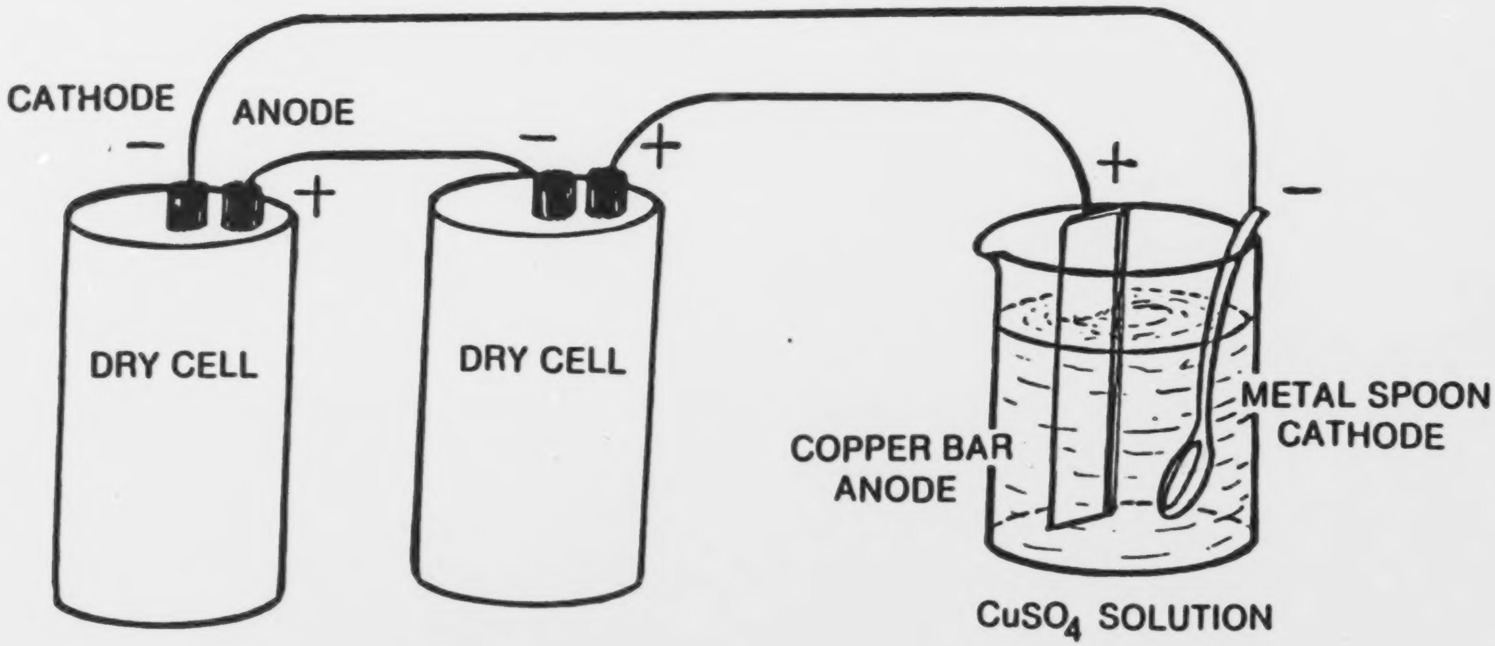
2. Surface Area
   - Area of Circle = πr^2
   - Area of Rectangle = $l \times w$
   - S.A. of cylinder = $2\pi r h$
   - S.A. of cube = s^3

3. $I = \frac{E}{R}$ Current = Voltage ÷ Resistance

   (AMPS. = Volts ÷ OHMS)

4. Multiplication of decimals
5. Scientific notation

COPPER ELECTROPLATING


CATHODE
ANODE
−
+
−
+
+
−
DRY CELL
DRY CELL
METAL SPOON
CATHODE
COPPER BAR
ANODE
$CuSO_4$ SOLUTION

COPPER ELECTROPLATING

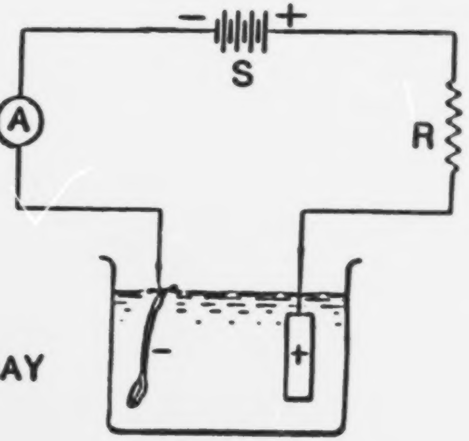
SCIENCE CONCEPTS

FARADAY'S LAW:

THE WEIGHT OF THE METAL DEPOSITED ON THE CATHODE DURING ELECTROLYSIS IS DIRECTLY PROPORTIONAL TO THE QUANTITY OF ELECTRIC CHARGE PASSING THROUGH THE CIRCUIT. (I.E., TO DOUBLE THICKNESS, DOUBLE THE CHARGE)

1 FARADAY DEPOSITS 1 CHEMICAL EQUIVALENT

MATH CONCEPTS



$$\text{CHEMICAL EQUIVALENT} = \frac{\text{ATOMIC WEIGHT}}{\text{VALENCE}}$$

$$\text{AMPERES} \times \left(3.731 \times 10^{-2}\right) = 1 \text{ FARADAY}$$

TITLE: Construction of a Deck

DESCRIPTION:

The Mathematical and Scientific concepts involved in construction of a pressure - treated wood deck are illustrated in these trans-parencies. In particular the emphasis is on a post and beam deck with one end attached to the house. The discussion centers on (1) The post ground connection: (2) The Beam - House attachment; (3) The post - beam interaction.

SCIENCE CONCEPTS:

1. Torque - Counterclockwise torque = clockwise torque
   Torque = Force x Distance from a selected point
   -Formula-

2. Post size depends on loads - compression formula:

   $S = \frac{P}{A}$

   S= Compressive strength of post
   P = Total Force on Post cross section
   A = Area of post end
3. Chemical treatment of materials to prevent rot.
4. Gravel bed to allow drainage.
5. Determing bolt size depends on load shear.

   -Formula-

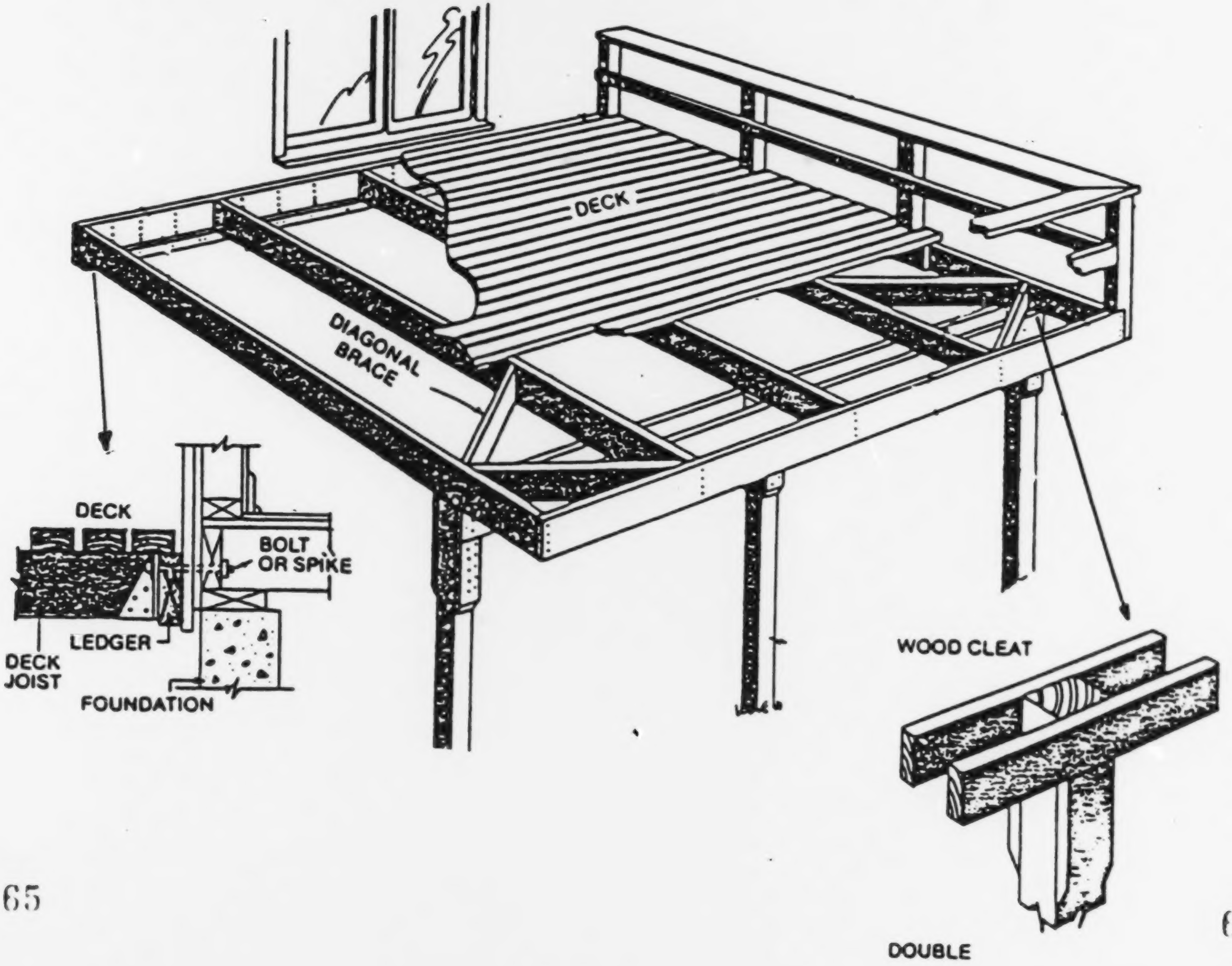
   $S_s = \frac{P}{A_s}$

   S_s = Shearing stress in P. S. I.
   P = Force on Bolts
   A_s = Area of Bolt end
6. Hydration (curing) of concrete happens in two stages (Fast and slow, see graph)

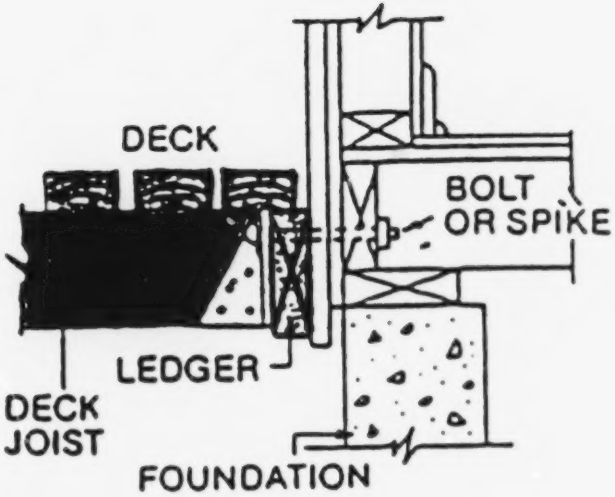
MATH CONCEPTS:

1. Determine dimensions of a deck
2. Estimate materials (lumber, nails, concrete, bolts, etc.)
3. Make joist perpendicular to ledger (Pythagrean Theorom)
4. Set posts perpendicular to ground
5. Level joist from ledger and level beam a long post
6. Measure distance on ledger for joist hangers.
7. Determine the area of deck for staining (A = 1 x w)
8. The sum of the beams and post for the correct bolt length.

CONSTRUCTION OF A DECK


DECK
DIAGONAL BRACE
DECK
BOLT OR SPIKE
LEDGER
DECK JOIST
FOUNDATION
WOOD CLEAT
DOUBLE

CONSTRUCTION OF A DECK FOUNDATION WALL AND LEDGER


DECK
BOLT OR SPIKE
LEDGER
DECK JOIST
FOUNDATION

MATH CONCEPTS

Volume = length x width x height

Density = $\frac{\text{mass}}{\text{volume}}$

W_{Deck} Weight = D x V x N (total boards)

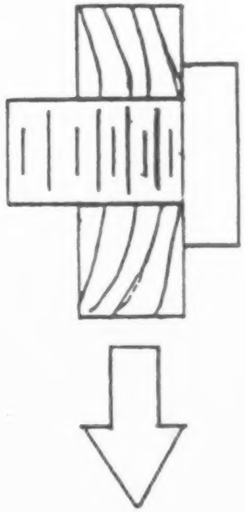
B_W(Weight supported by beam) = $\frac{W}{2}$

X(No. of Joist) = $\frac{B_l(\text{length of beam})}{24''\ (\text{Distance between beams})}$

J(weight supported by each joist) = $\frac{BW}{X}$

CONSTRUCTION OF A DECK FOUNDATION WALL AND LEDGER

SHEAR STRENGTH


BOLT
SHEAR FORCE

S_s = Shearing Stress in p.s.i.

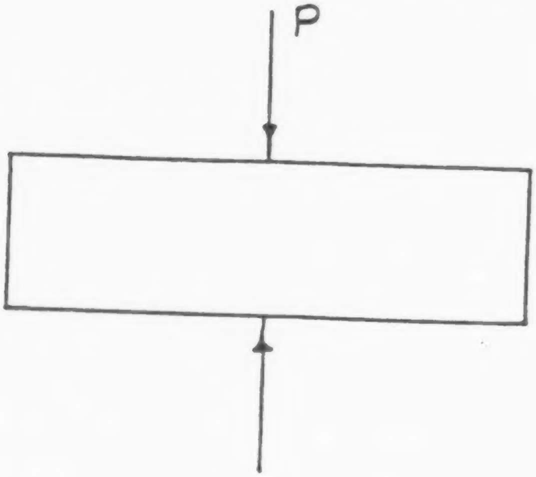
P = Force on Bolt

A_s = Area of Bolt End

$$S_s = \frac{P}{A_s}$$

BEAM AND POST

COMPRESSIVE STRENGTH



FORCE UPWARD

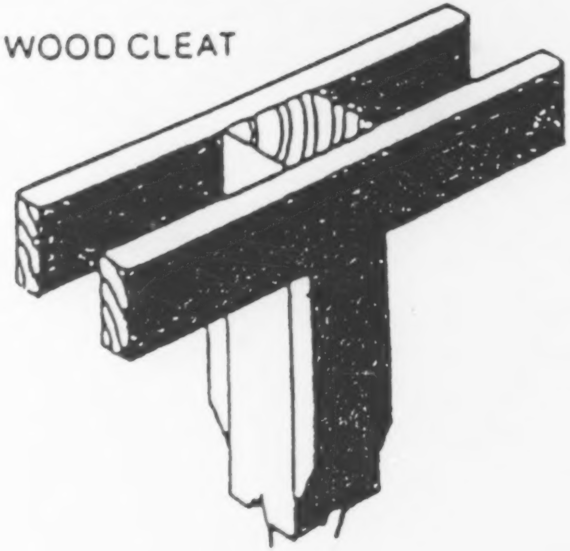
P = Total Force on Post Cross Section

A = Area of Post End

S = Compressive Strength of Post

$$S = \frac{P}{A}$$

CONSTRUCTION OF A DECK BEAM AND POST



MATH CONCEPTS

Volume = Length x Width x Height

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

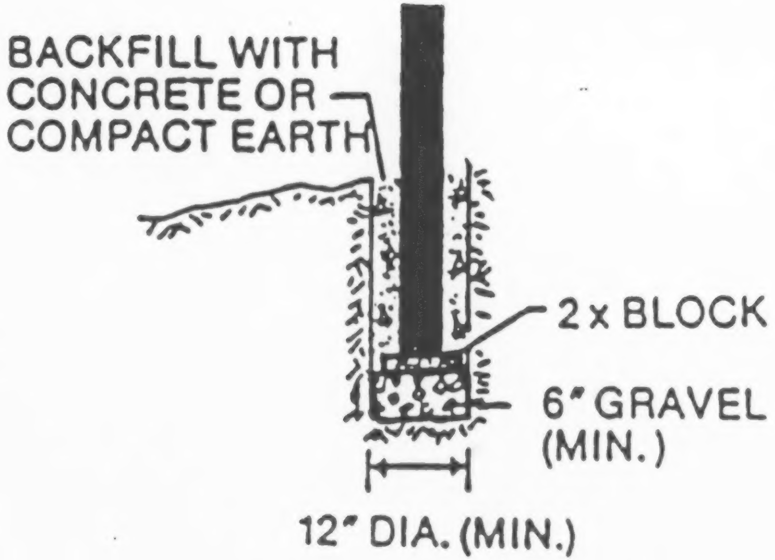
$$W_{\text{(Deck Weight)}} = D \times V \times N_{\text{(Total boards)}}$$

$$L_{W\text{(Weight supported by Ledger)}} = \frac{W}{2}$$

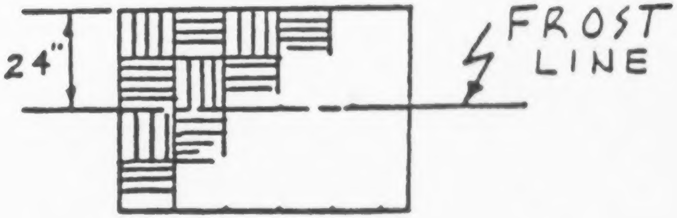
$$X_{\text{(no. of Joist)}} = \frac{L_{1}\text{(Length of Ledger)}}{24''\text{ (Distance between Joists)}}$$

$$J_{\text{(Weight supported by each Joist)}} = \frac{L_W}{X}$$

CONSTRUCTION OF A DECK
POST DETAILS


BACKFILL WITH CONCRETE OR COMPACT EARTH
2 x BLOCK
6" GRAVEL (MIN.)
12" DIA. (MIN.)

• FROST LINE •


24"
FROST LINE

TITLE: Dimensional Change In Wood

DESCRIPTION: This transparency illustrates the dimensional change in wood in three principal directions; tangential, radial, and longitudinal due to loss or gain of bound water from the cell walls.

SCIENCE CONCEPTS:

1. 2" x 4" x 8' piece of wood may contain up to 3 gallon of water when cut. This is due to the water brought up the tree through the transpiration process.

2. Fiber Saturation Point: After wood is cut down it begins to dry. The fluid in the wood cell cavities,(xylem cells) or the cytoplasmic fliud, is the first to leave the wood cells. (the familiar name of this fluid is called free water) When all of this fluid has left the cells the saturation point has been reached. "Fiber Saturation Point" indicates that the cell wall still contains all the original fluid (the familiar name of this fluid is called bound water), but cytoplasmic fluid has left. This is when the wood begins to shrink. Wood will lose mass before this point, but it won't shrink until it is taken beyond "Fiber Saturation Point". "Fiber Saturation Point" for woods vary between 23 to 30% moisture content. (average Fiber Saturation Point is 28%).

3. Beyond "Fiber Saturation Point" wood cells shrink in diameter because cell wall material begins to shrink.

4. Within each plant cell wall there are minute fibers called fibrils that have an affinity for water molecules. This is achieved through hydrogen bonding. When the water is taken out of the cell wall the fibrils move closer together and the cell walls shrink. Ultimately the cells' diameter is decreased.

5. Density - woods that are more dense (actual amount of wood/unit of area) shrink and swell more than lighter ones with a given change in moisture content.

6. Equilibrium Moisture Content - (EMC) = The amount of bound water eventually contained in a piece of wood. A balance is eventually reached at which the wood is no longer gaining or losing moisture.

TITLE: Dimensional Change in Wood

DESCRIPTION: This transparency illustrates the dimensional changes in wood in three principal directions: tangenial, radial and longitudinal due to loss or gain of bound water from the cell walls.

MATH CONCEPTS:

1. Wood is air dried by stacking the wood either on edge or at an angle in layers separated by cross pieces (stickers) for one to three months. The minimum moisture content is between 12-15% with no more than an average of 19%.

2. Wood is kiln dried by stacking in piles, applying steam at low heat, reducing the steam and increasing the heat so the moisture decreases. The minimum moisture content is less than 10%, preferably 7-8%.

3. When cell walls absorb all they can hold and there is no water in the cavities the fiber saturation point is reached. The fiber saturation point varies from about 23-30% moisture content. From green to 28% there is little or no shrinkage.

4. One factor that affects shrinkage is rays. Ray effects help prevent vertical-grained or quarter-sawed wood from shrinking as much as plain-sawed or flat-grained.

5. The density of wood affects shrinkage. Heavier woods shrink and swell more than lighter ones with a given change in moisture content.

6. Hardwoods-the moisture content may be as high as 60-100%.

7. Total shrinkage is given as a percent.

$$S = \frac{D_g - D_{od}}{D_g} \times 100,$$

where S is total shrinkage, Dg is dimension when green and Dod is dimension when overdried.

A. $S = S_t + S_r + S_l$

B. S_t is tangential shrinkage which is shrinkage that is perpendicular to the grain and parallel to the growth rings. It is greater than radial shrinkage and ranges from 4% in teak to 12.7% in overcup oak. It averages 7.95% or 8%.

C. S_r is radial shrinkage which is only perpendicular to the growth rings. It ranges from 2.2% in teak to 8.5% for eastern hapshorn beam. It averages 4.37% or 4%.

D. S_{ℓ} is longitudinal shrinkgage is negligible in normal wood. In juvenile or reaction wood it may be 2% or 20 times that of normal wood.

Total shrinkage along the grain is normally only about 0.1%.

8. The ratio of tangential to radial shrinkage averages 1.8 over the entire range of moisture content - from fiber saturation point to over-dry — shrinkage is approximately proportioned to moisture loss.

9. Estimated shrinkage and swelling is determined by

$$\Delta D = D_i S \left(\frac{\Delta mc}{fsp} \right)$$

where ΔD is changed in dimension due to shrinkage, D_i is initial dimensions, S is total shrinkage , ΔMC is change in moisture content and fsp is fiber saturation point whose average value is 28%.

10. Percentage: The meaning of percentage as well as how to find the percent of a number. Comparisions of percentages need to be clarified.

11. Solving algebraic formulas and using transpositions of algebraic formulas.

12. Measuring linear footage.

13. Measuring moisture content and expressing the results in percentage increase or percentage decrease.

14. Finding averages of moisture content percents.

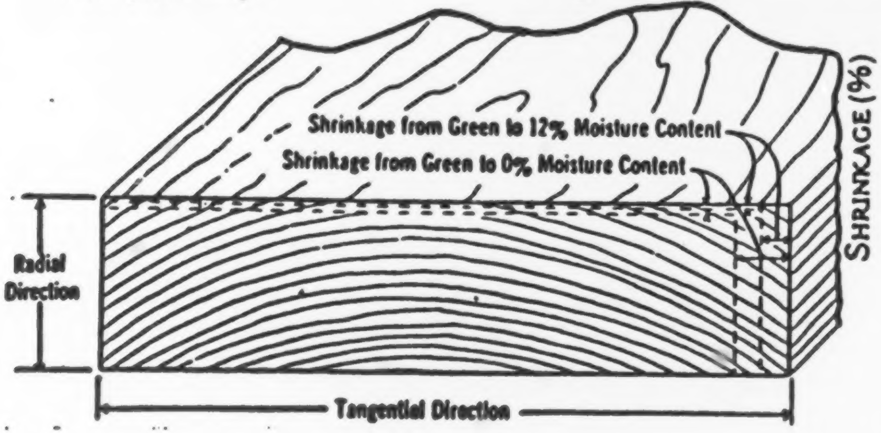
15. Reading charts to determine density (specific gravity) of wood. This refers to the amount of wood per square unit.

16. Ratios: Used basically to compare tangential to radial shrinkage over the entire range of moisture content.

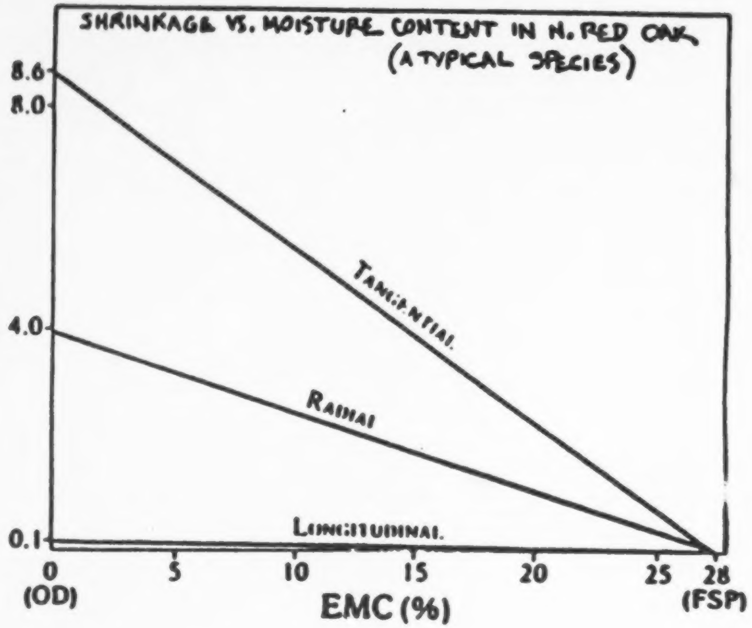
DIMENSIONAL CHANGE IN WOOD

S = SHRINKAGE
D = DIMENSION
g = GREEN
od = OVEN DRY

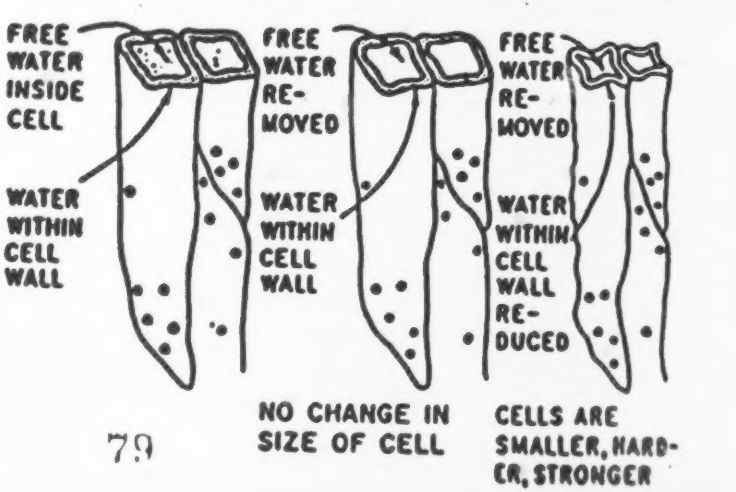
$$S = \frac{(D_g - D_{od})}{D_g} \times 100.$$



Shrinkage from Green to 12% Moisture Content
Shrinkage from Green to 0% Moisture Content
Radial Direction
Tangential Direction



HOW A CELL CHANGES IN SIZE AS THE WATER IS REMOVED



FREE WATER INSIDE CELL
WATER WITHIN CELL WALL
FREE WATER REMOVED
WATER WITHIN CELL WALL
NO CHANGE IN SIZE OF CELL
FREE WATER REMOVED
WATER WITHIN CELL WALL REDUCED
CELLS ARE SMALLER, HARDER, STRONGER

SHRINKAGE

Change in dimension due to loss of moisture below the fiber saturation point, expressed numerically as a percentage of green dimension.

FIBER SATURATION POINT (FSP)

The condition of moisture content where cell walls are fully saturated but cell cavities are empty of free water.

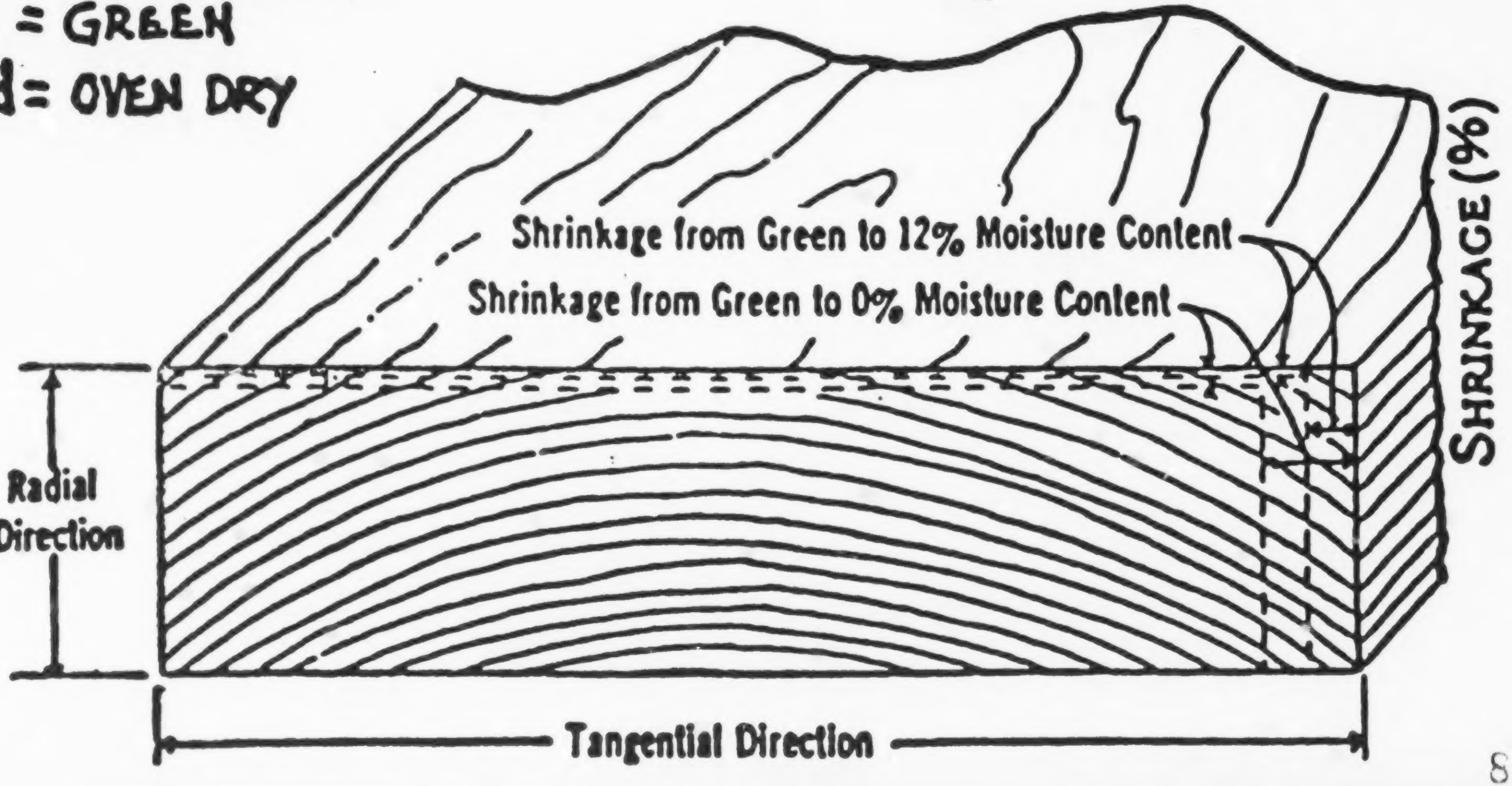
EQUILIBRIUM MOISTURE CONTENT (EMC)

The moisture content eventually attained in wood exposed to a given level of relative humidity and temperature.

DIMENSIONAL CHANGE IN WOOD

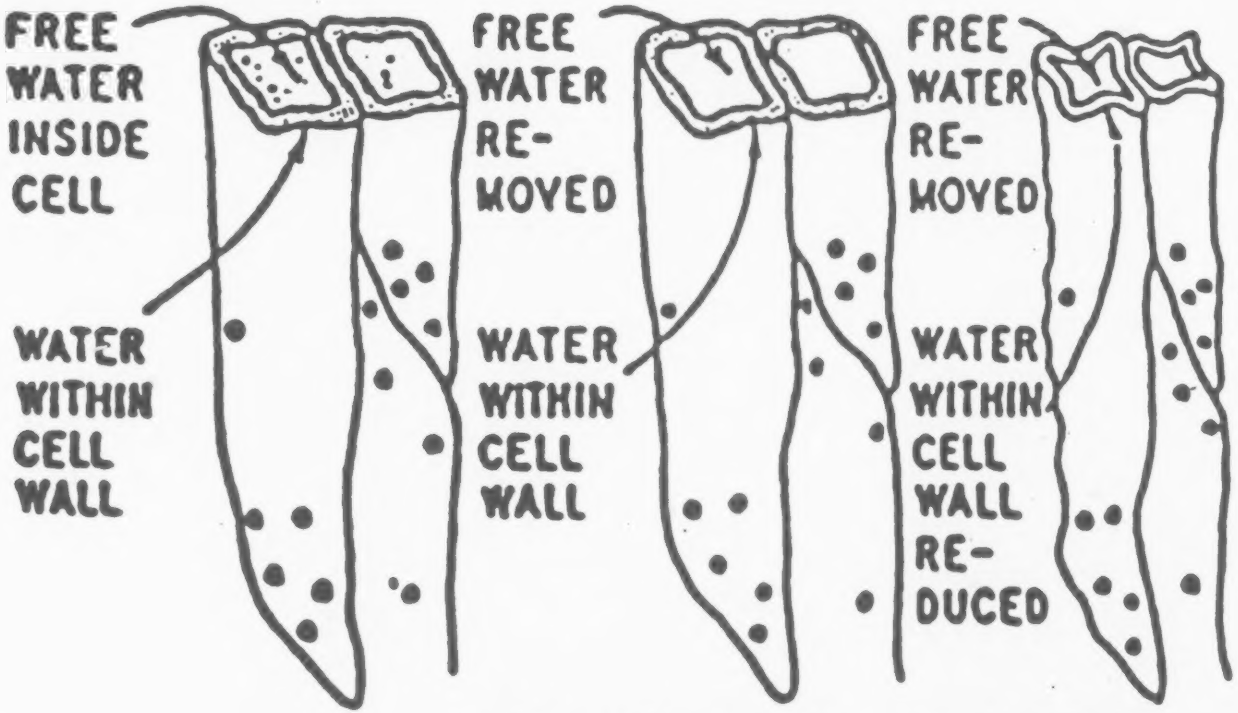
S = SHRINKAGE
D = DIMENSION
g = GREEN
od = OVEN DRY

$$S = \frac{(D_g - D_{od})}{D_g} \times 100$$


Shrinkage from Green to 12% Moisture Content
Shrinkage from Green to 0% Moisture Content
SHRINKAGE (%)
Radial Direction
Tangential Direction

DIMENSIONAL CHANGE IN WOOD

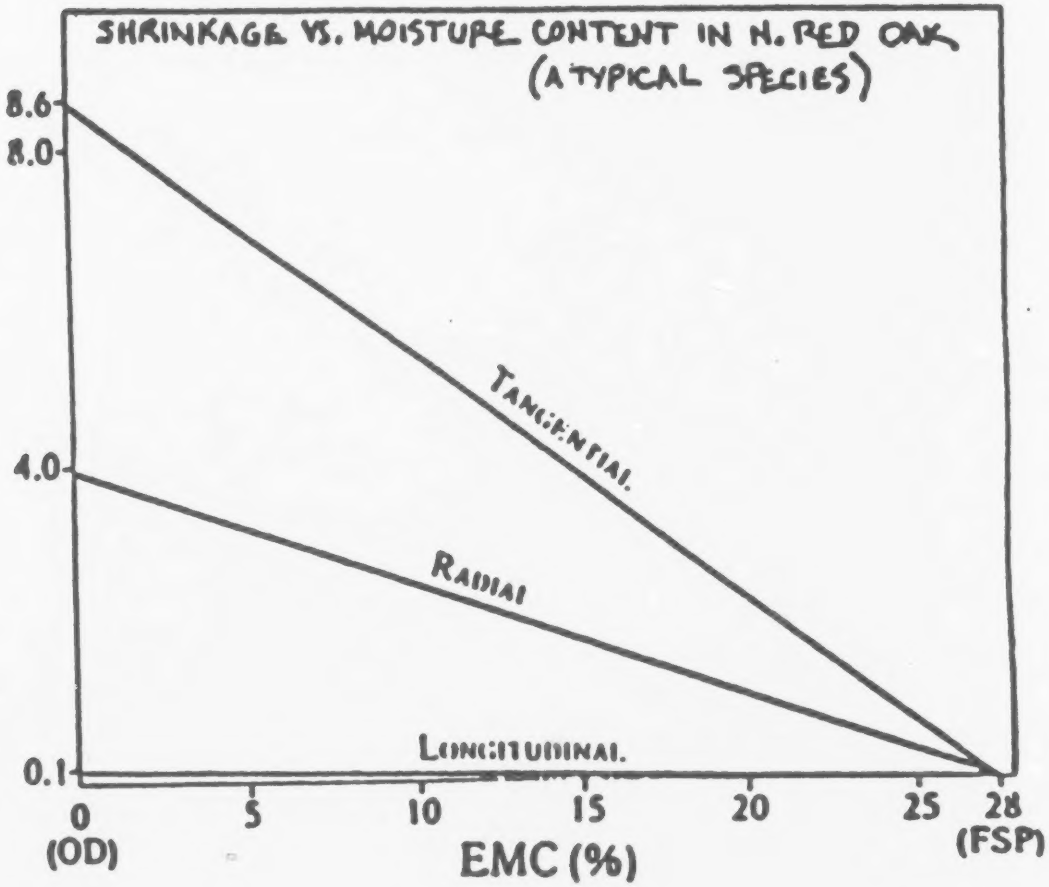
HOW A CELL CHANGES IN SIZE AS THE WATER IS REMOVED


FREE WATER INSIDE CELL
WATER WITHIN CELL WALL
FREE WATER REMOVED
WATER WITHIN CELL WALL
FREE WATER REMOVED
WATER WITHIN CELL WALL REDUCED

NO CHANGE IN SIZE OF CELL

CELLS ARE SMALLER, HARDER, STRONGER

DIMENSIONAL CHANGE IN WOOD



Title: Hammer Technology

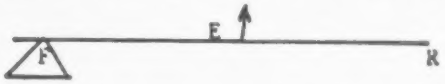
Description:

This transparency deals with the use of a hammer and how the science concept of levers affect this use. It also shows the math concepts involved in determining hammer blow force.

Science Concepts:

1. The action of the hammer works on the principle of the lever whether driving or pulling a nail.

2. This is an example of a third class lever:



F is the fulcrum, E is the effort, R is the resistance.

3. When driving a small nail, the fulcrum would be at the wrist, the effort at the hammer head, and the resistance would be exerted against the hammer head.

4. When driving a medium size nail, the elbow becomes the fulcrum because the stroke should be done with a straight arm from the elbow. The longer effort arm will produce more force.

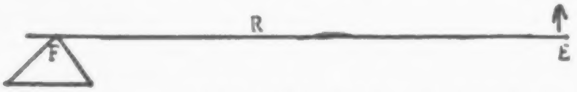
5. When driving a large nail, the shoulder should become the fulcrum thus forming a longer effort arm with resulting greater force.

6. Density (weight per unit volume) is the single most important indicator of strength in wood and may predict such characteristics as hardness.

7. Specific gravity is the density of a material as compared to the density of water.

8. A wood with greater specific gravity would require greater force when hammering a nail.

9. Pulling a nail is an example of using a second class lever.



10. When pulling a nail the hammer head is the fulcrum, the nail position is the point of resistance and the end of the hammer head would be the point at which the effort is applied.

11. When pulling a nail after the nail is out about one inch it is best to place a block of wood next to the nail so that the hammer head rests on the block. Thus, the mechanical advantage is increased.

Title: Hammer Technology

Description:

This transparency deals with the use of a hammer and how the science concept of levers affect this use. It also shows the math concepts involved in determining hammer blow force.

Math Concepts:

1. Forces involved, using the hammer as a lever

   a. E.A = Effort Arm
   R.A = Resistance Arm
   E.F = Effort Force
   R.F = Resistance Force
   M.A = Mechanical Advantage

   b. Law of moments or torque is used in nailing to find effort and resistance or the effort arm and resistance arm. The law states that the effort force times the effort arm equals the resistance force times the resistance arm.

   $$(E.F \times E.A = R \times R.A)$$

   c. The mechanical advantage in nailing is the ratio of resistance force to effort force or effort arm to resistance arm.

   $$\left(M.A = \frac{R.F}{E.F} = \frac{E.A}{R.A}\right)$$

2. The hammer blow as force and the law of momentum.

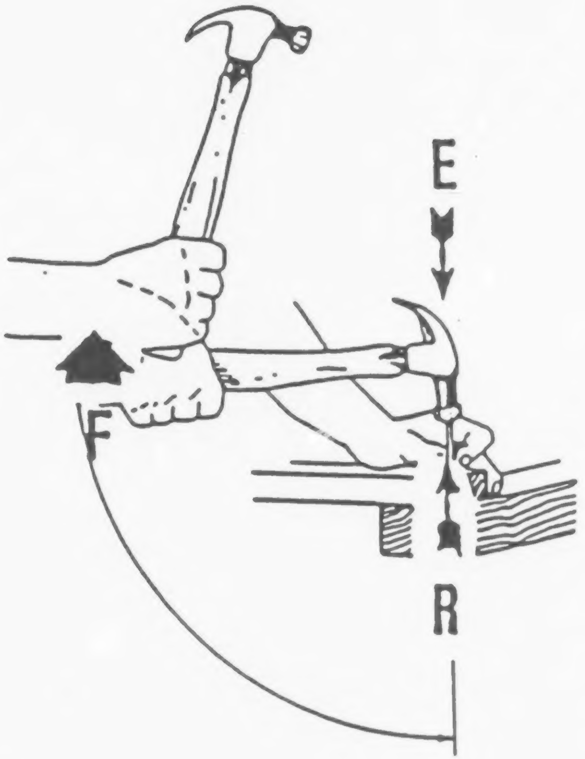
   a. When a hammer acts upon a nail, it changes the momentum of the nail. This change of momentum is proportional to the applied hammer force and to the arc length of the hammer swing.

   b. For the student, one may say that the force of the hammer blow equals acceleration times the hammer head weight, divided by the pull of gravity (32 ft. sec.).

   c. F = Force of hammer blow
   w = Hammer head weight
   a = Swinging arc acceleration of hammer
   g = Pull of gravity (32 ft. sec.)

   Therefore, $F = \frac{wa}{g}$

HAMMER TECHNOLOGY

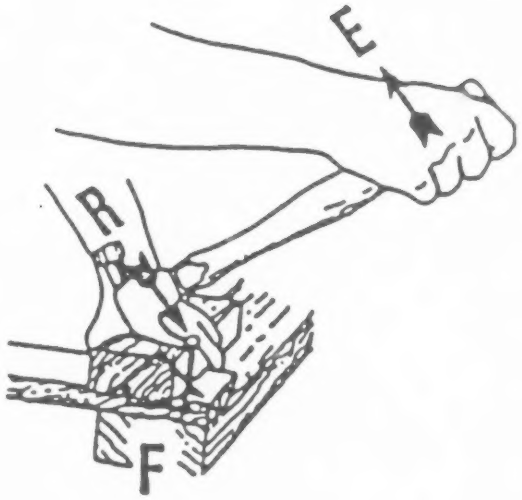


HAMMER FORCE

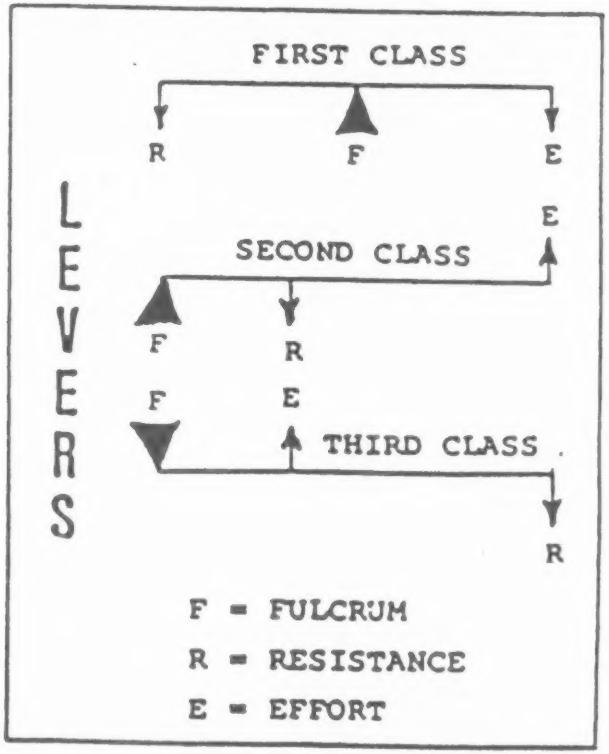
F_1 = FORCE OF HAMMER BLOW
W = HAMMER HEAD WEIGHT
a = SWINGING ARC ACCELERATION OF HAMMER
g = PULL OF GRAVITY

$$F_1 = \frac{W \times a}{g}$$

HAMMER TECHNOLOGY



91


LEVERS
FIRST CLASS
R
F
E
E
SECOND CLASS
F
R
F
E
THIRD CLASS
R

F = FULCRUM
R = RESISTANCE
E = EFFORT

92

TITLE: Hardening of Steel

DESCRIPTION:

The process of steel hardening is described in terms of a transformation from a ferrite to an austenite to a martensite form which is temperature dependent. This process is also described in terms of what happens on a molecular level.

SCIENCE CONCEPTS:

Crystals: The term "crystal" (derived from the Greek word meaning ice and originally applied only to crystals of quartz which the ancient philosophers believed to be congealed water) refers to the regular polyhedral form bounded by smooth surfaces which is assumed by a chemical compound (or element) under the action of its interatomic forces, when passing under suitable conditions from the state of liquid (melt or solution) or gas to that of a solid. Thus a crystal is characterized by its definite external form which is an important manifestation of a definite ordered internal structure - a fact which was proved conclusively in 1912 by von Laue by the diffraction of x-rays from a crystal acting as a three-dimensional grating.

Heat Treatment of Steel: Steel is an alloy of Iron and Carbon (up to 2% by weight) and possibly other elements. When certain of these alloys are held near 850°C for, say 1 hour (this is called austenitizing) and then quenched rapidly in water (or oil) at room temperature, there is a large increase in strenght and hardness. The tensile yield strength may increase from 80,000 to 240,000 pounds per square inch. Whereas the material could be readily machined before the heat treatment, it can be machined only by grinding after the heat treatment.

Iron: Element number 26, atomic mass 55.85

Carbon: Element number 6, atomic mass 12.000

Critical Temperature: The temperature at which one crystal form shifts to another is called the critical temperature or critical point. This temperature is reported to be 850° C but actually the change takes place over a range of temperature.

Hardness

The hardness of the steel can be greatly increased by the process of heating the steel (in the ferrite form) a body - centered cubic structure above the critical temperature. This will result in the formation of austenite, a face - centered cubic structure which can dissolve 40 times more carbon than the ferrite. By quick cooling (quenching) the austenite is converted to martensite which is in a body - centered tetragonal form. The presence of a much greater amount of dissolved carbon plus the more compact structure of the martensite makes the steel much harder than it was originally. The carbon is in the crystal lattice in the interstitial spaces, (spaces between the normal location of the iron atome in the crystal lattice). The amount of carbon in the steel doesn't change but its location changes because the ferrite form of steel has most of the carbon tied up as Fe_3C. In the austenite and martensite form the C has been released from the Fe_3C and made available to be dissolved into the crystal lattice.

RELATED VOCABULARY

1. Alloy
2. Steel
3. Carbon
4. Iron
5. Hardness
6. Brinell Test
7. Rockwell Test
8. Crystal
9. Atom
10. Molecule
11. Temperature
12. element
13. body - centered cubic
14. face - centered cubic
15. body - centered tetragonal
16. Scratch Test

TITLE: Hardening of Steel

DESCRIPTION:

The process of steel hardening is described in terms of a transformation from a ferrite to an austenite to a martensite form which is temperature dependent. This process is also described in terms of what happens on a molecular level.

MATH CONCEPTS:

1. Ratio = $\frac{Lfcc}{Lbct}$

Lfcc - linear interatomic distance in the crystal of Fe for a face-centered cubic crystal

Lbct - Linear interatomic distance in the crystal of Fe for a body-centered tetragonal

Before Transformation

$$\text{Ratio} = \frac{Lfcc}{Lbct} = \frac{\sqrt{2}}{1}$$

After Transformation

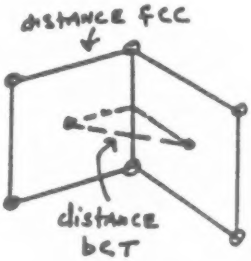
$$1.00 < \frac{Lfcc}{Lbct} < 1.08$$

2. Right triangle: Pythagorean Relationship

X - Distance in b c t -

$$X^2 = (\tfrac{1}{2})^2 + (\tfrac{1}{2})^2$$

$$X = \sqrt{2}$$



$$\text{Ratio} = \frac{\sqrt{2}}{1}$$

3. Proportionality When two parts/ of a substance are at different temperatures then there is a continous distribution of temperature in between. If we consider a slab of material of cross sectional area A and thickness X, whose faces are kept at different temperatures. Then heat Q will flow perpendicularly to the faces for a time t.

Q is proporational to t as well as A
Q is also proportional to Rate of change of

temperature with respect to distance
This leads to the relationship

by introducting k - constance of proportionality called Thermal conductivity

we get

where Q - amount of heat transferred
t - time
T temperature at Hot side
T. temperature at cold side
L length of slab
K thermal conductivity

4. Solving Equations
Amount of Heat transferred $Q = K \; A \left(\frac{T_2 - T_1}{L}\right)$

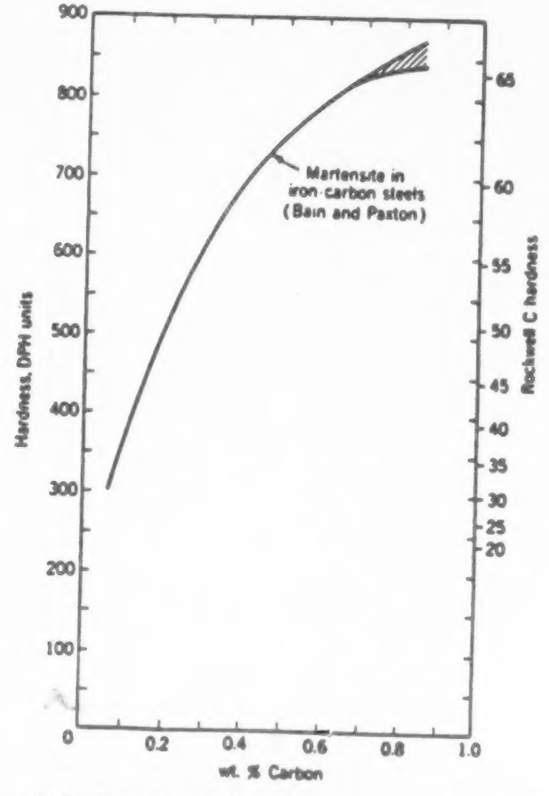
5. Geometry
configuration of crystals
cubic, tetragonal, rdombohedral orthorhombic
a=b=c a=b=c a=b=c a=b=c

6. Graphing in Space: The lattice coordinates are used to descibe the position of a point relative to the cell orgin. The position is measured in units of a long a of b along b and of c along c. Thus the position of the atom In the body center of the cube is 1/2 1/2 1/2, or in general, u v w,

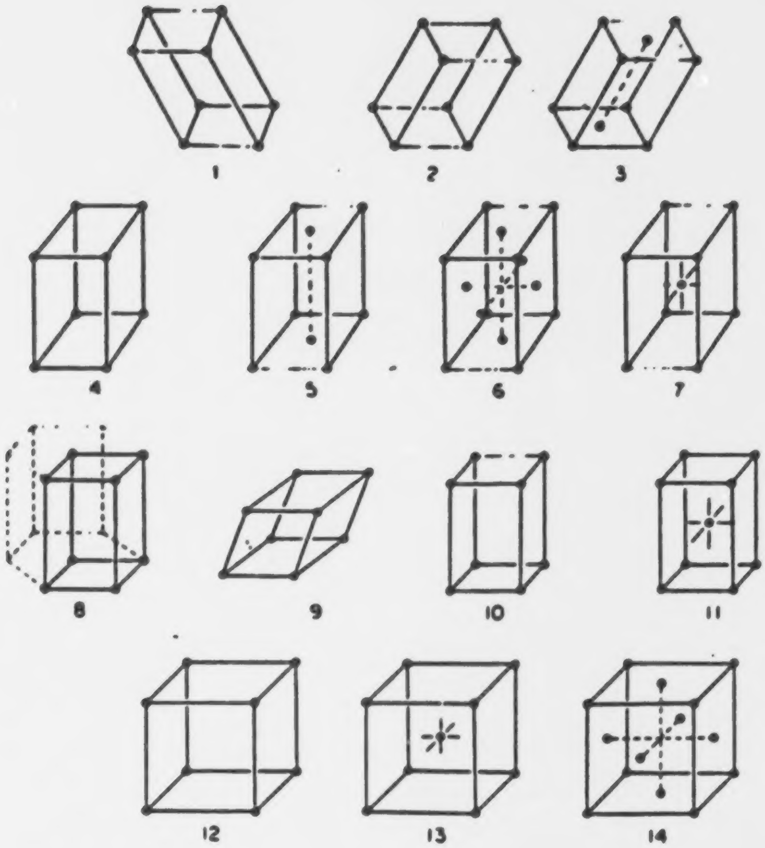
so a vector R from the orgin to the point u v w is given by

$$R = u\,a + v\,b + w\,z$$

7. Graphing Relationship of two variables with a resulting non-linear curve.

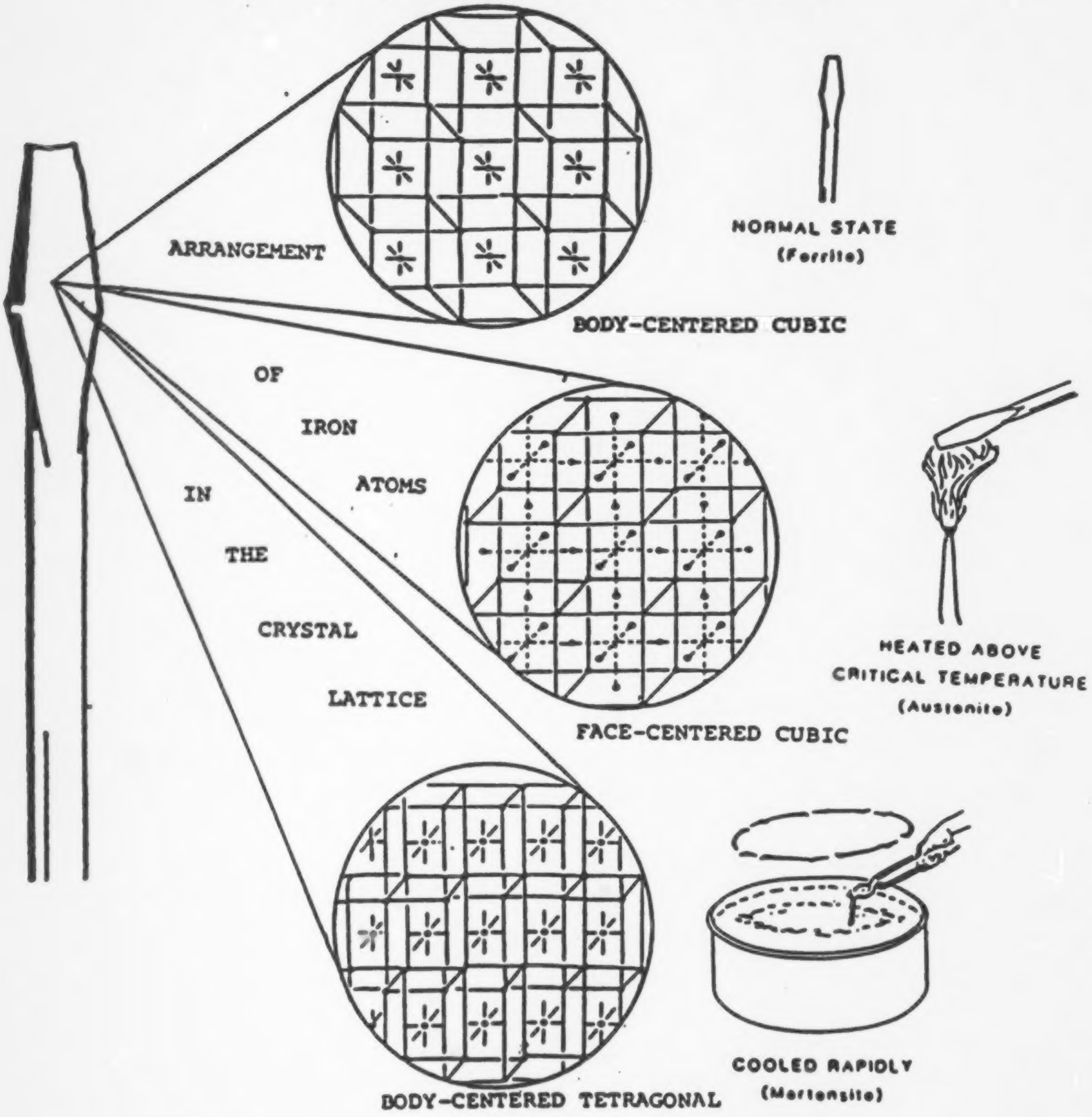


Effect of carbon on the hardness of austenite and on the hardness of martensite. The shaded area of the upper curve represents the effect of retained austenite.



Number in Figure 10.3.4	Space Lattice	Relationship Between a, b, and c Axes	 Angles	Corresponding Crystal Systems	Lattice Points in the Conventional Unit Cells	Minimal Symmetry
1	Triclinic	$a \neq b \neq c$	$\alpha \neq \beta \neq \gamma$	Triclinic	1	Onefold axis
2	Simple monoclinic	$a \neq b \neq c$	$\alpha = \gamma = 90° \neq \beta$	Monoclinic	1	One twofold axis
3	Base-centered monoclinic				2	
4	Simple orthorhombic	$a \neq b \neq c$	$\alpha = \beta = \gamma = 90°$	Orthorhombic	1	Three orthogonal twofold axes
5	Base-centered orthorhombic				2	
6	Face-centered orthorhombic				4	
7	Body-centered orthorhombic				2	
8	Hexagonal	$a = b \neq c$	$\alpha = \beta = 90°$; $\gamma = 120°$	Hexagonal	1	One sixfold axis
9	Rhombohedral	$a = b = c$	$\alpha = \beta = \gamma \neq 90°$, $< 120°$	Trigonal	1	One threefold axis
10	Simple tetragonal	$a = b \neq c$	$\alpha = \beta = \gamma = 90°$	Tetragonal	1	One fourfold axis
11	Body-centered tetragonal				2	
12	Simple cubic	$a = b = c$	$\alpha = \beta = \gamma = 90°$	Cubic	1	Four threefold axes
13	Body-centered cubic				2	
14	Face-centered cubic				4	

HARDENING OF STEEL


ARRANGEMENT
OF
IRON
ATOMS
IN
THE
CRYSTAL
LATTICE
BODY-CENTERED CUBIC
NORMAL STATE
(Ferrite)
FACE-CENTERED CUBIC
HEATED ABOVE
CRITICAL TEMPERATURE
(Austenite)
BODY-CENTERED TETRAGONAL
COOLED RAPIDLY
(Martensite)

FACTORS THAT DETERMINE HARDNESS

1. Carbon content
2. Temperature
3. Cooling time
4. Heating time

TITLE: HEAT TREATING OF METALS

CATEGORY: PROCESS

DESCRIPTION:

Heat treatment is a combination of heating and cooling operations. This process is timed and applied to a metal or an alloy in such a way that it will produce desired properties. It is utilized to strengthen, toughen, soften, or otherwise enhance properties of the metals.

SCIENCE CONCEPTS:

1. A crystal is a homogeneous solid whose atoms have a definite arrangement.
2. Crystallization is a chemical process by which a substance forms crystals from a molten or gaseous state from a saturated solution.
3. Exothermal reaction is a chemical reaction in which heat energy is released.
4. Temperature is the intensity of heat energy in a given object or region of space.
5. The procedure of heating and cooling is called heat treating.
6. To anneal is to heat or cool slowly.
7. Tempering is a relatively low temperature process in the heat treatment of steel that results in a balance of hardness and toughness.
8. Carburizing is a process where low carbon steel is heated in contact with carbon gas or other carbonaceous material. This process yields a tougher overall structure. This process is also called case hardening.
9. Nitriding is a process where steel is heated in an atmosphere of ammonia gas. This process yields a hardened, corrosion and wear resistant, high endurance metal.
10. Forging is deforming metal usually while it is hot into desired shapes with compressive force.

TITLE: HEAT TREATING OF METALS

CATEGORY: PROCESS

MATHEMATICAL CONCEPTS:

1. Fahrenheit/Centigrade temperature conversion

   $F = \frac{9}{5} C + 32$ $\qquad$ $C = \frac{5}{9} (F - 32)$

2. Graphing temperature-time relationships

3. Units of measure

4. Influence of temperature on the rate of reaction

   $$\ln \frac{k_1}{k_2} = \frac{E}{R} \quad \frac{1}{T_2} - \frac{1}{T_1}$$

   E = energy of activation per gram mole of a substance
   k_1 and k_2 = specific reaction rates at absolute temperatures T_1 and T_2, respectively
   R = gas constant

5. H-factor ratio of the heat transfer factor F to the thermal conductivity k of the materials

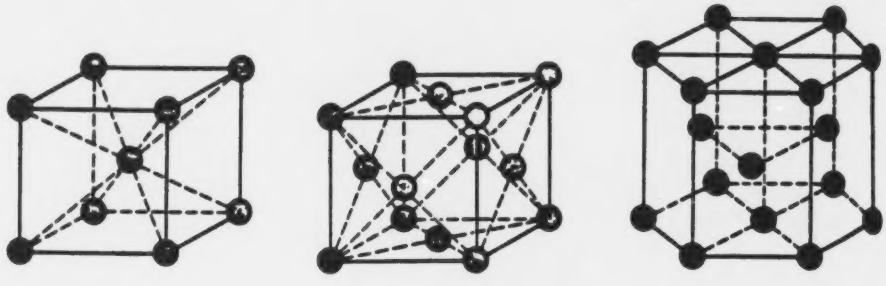
   $H = \frac{F}{k}$ $\qquad$ F = heat transfer factor: Btu/in^2 sec °F
   k = thermal conductivity: Btu/in sec °F

   The least cooling rate H would be a decimal quantity like 0.2. The maximum severity would be represented by an H-value equal to infinity.

6. Geometric shapes of crystal structure--

   a) body-centered cubic
   b) face-centered cubic
   c) hexagonal close-packed
   d) cubic
   e) body-centered tetragonal
   f) rhombohedral

   The 3 most common crystal patterns of unit cells are shown below.



MATHEMATICAL CONCEPTS:

(CONTINUED)

7. Chemical formula analysis:

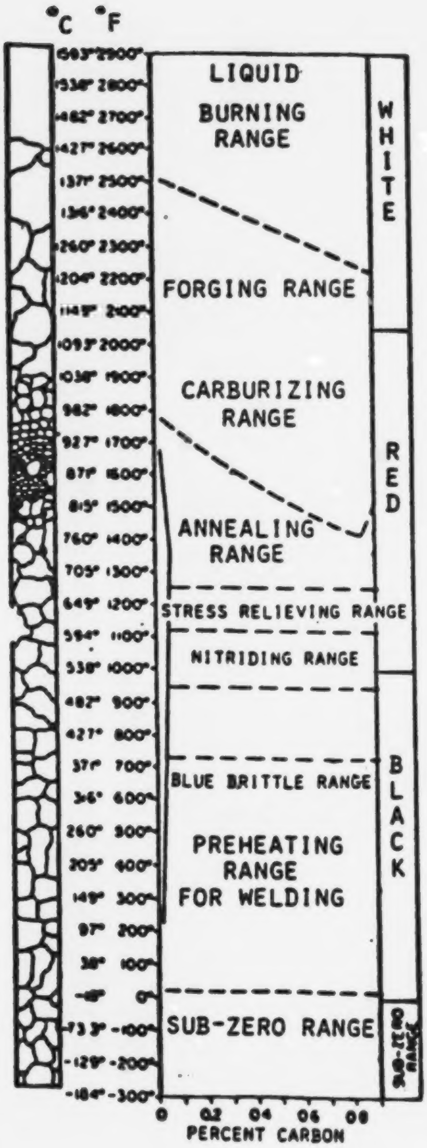
   Nitriding process--

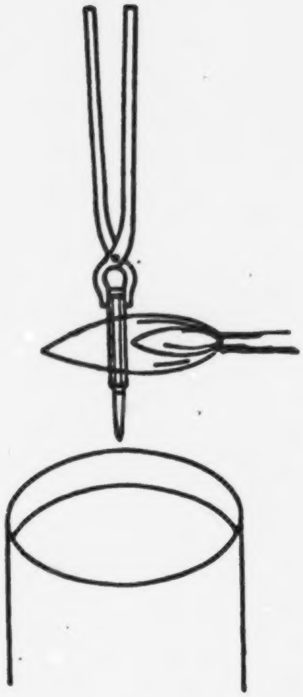
   $4\ NH_3 + 5\ O_2 \longrightarrow 4\ NO + 6\ H_2O + 216{,}240$ calories

   Carburizing process--

   $2\ CO + 3\ Fe \longrightarrow Fe_3C + CO_2$

HEAT TREATING OF METALS





SCIENCE CONCEPTS

EXOTHERMIC REACTIONS

HEAT TREATING

CARBURIZING

TEMPERATURE

NITRIDING

TEMPERING

MATH CONCEPTS

TEMPERATURE CONVERSION

UNITS OF MEASURE

GRAPHING

INFLUENCE OF TEMPERATURE
ON THE RATE OF REACTION

HEAT TRANSFER RATIO

CHEMICAL FORMULA ANALYSIS

GEOMETRIC SHAPES OF CRYSTALS

TITLE: WALL CONSTRUCTION

CATEGORY: CONSTRUCTION

DESCRIPTION:

The exterior walls of a wood-frame house normally consist of studs, interior and exterior coverings, windows and doors, and insulation.

Knowledge and understanding of the properties of various building materials and of scientific processes and natural phenomena are useful in construction planning. Geometry and trigonometry are useful in building strong, well-fitting structures.

SCIENCE CONCEPTS:

1. Force is a push, pull, or twist.
2. Stress is the applied force per unit of area to which the force is applied.

   $$\text{Stress} = \frac{\text{Force}}{\text{Area}} = \frac{F}{A}$$
3. Insulation refers to the ability of a substance to resist the transfer of heat.
4. The resistance of a material to the transfer of heat depends on its composition and physical characteristics.
5. Heat may be transferred by conduction, convection, and reflection.
6. A good insulating material has a large volume of "dead air" space and a shiny surface.
7. Warm air carries more moisture than cool air.
8. Condensation occurs when warm, moist air is cooled below its dew point.

TITLE: WALL CONSTRUCTION

CATEGORY: CONSTRUCTION

MATHEMATICAL CONCEPTS:

1. A triangle is a closed, three-sided polygon. The two shorter sides of the triangle are called legs and the longest side is called the hypotenuse.

2. A right angle (square angle) has a measure of 90 degrees.

3. A right triangle has an angle that measures 90 degrees. The three sides of a right triangle have a special relation given in the Pythagorean Theorem:

   $\text{Hypotenuse}^2 = \text{Leg1}^2 + \text{Leg2}^2$

4. Linear measure refers to a measure of length. (Ex. Feet, Inches)

5. Perimeter is the linear measure of the boundaries of a figure or a structure.

6. Circumference is the linear measure of the boundary of a circle.

7. Common perimeter/Circumference formulas

Square	Perimeter	= 4 x side
Rectangle	Perimeter	= 2 x (length + width)
Circle	Circumference	= 2 x 3.14 x radius
	Circumference	= 3.14 x diameter

8. Square measurement is a measure of area. (Ex. Square Yard)

9. Common area formulas:

Square	Area = side x side
Rectangle	Area = length x width
Triangle	Area = ½ x base x altitude
Circle	Area = 3.14 x radius x radius

10. A board foot is defined as the equivalent of a piece of wood measuring one foot wide, one foot long, and one inch thick.

11. The formula for board feet is:

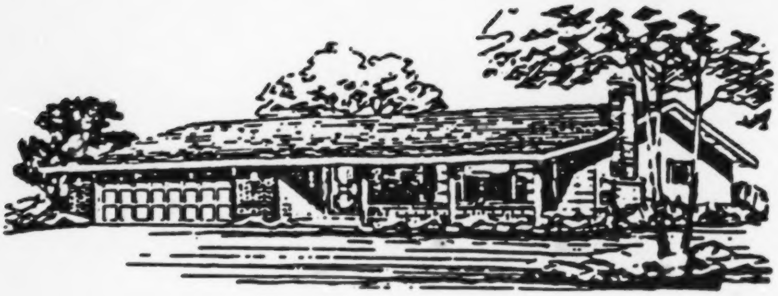
    Board Feet = Thickness (inch) x Width (feet) x Length (feet)

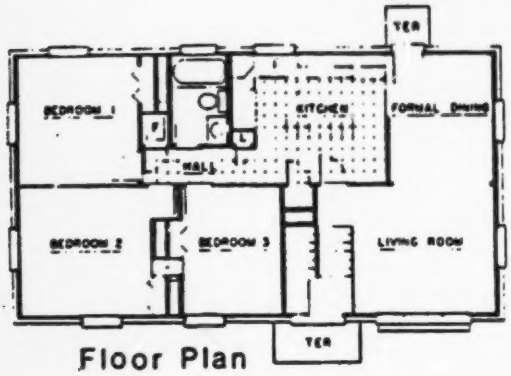
    or

    $$\text{Board Feet} = \frac{\text{Thickness (inch)} \times \text{Width (inch)} \times \text{Length (inch)}}{144}$$

12. A common practice, and a fairly accurate way of estimating studs used is to allow one stud for every linear foot of wall and partition, when studs are set 16 inches on center. This surplus allows for the doubling at corners and around openings.

HOUSE CONSTRUCTION




TER
BEDROOM 1
KITCHEN
FORMAL DINING
HALL
BEDROOM 2
BEDROOM 3
LIVING ROOM
TER

Floor Plan

SCIENCE CONCEPTS

Force / Stress

Insulation

Heat Transfer

Condensation

MATH CONCEPTS

Linear Measure

Square Measure

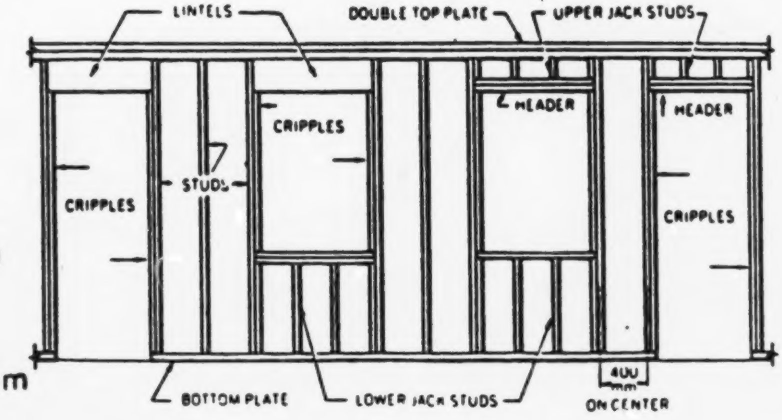
Board Measure

Material Estimation

Angle Measure

Pythagorean Theorem

WALL UNIT


LINTELS
DOUBLE TOP PLATE
UPPER JACK STUDS
HEADER
HEADER
CRIPPLES
STUDS
CRIPPLES
CRIPPLES
BOTTOM PLATE
LOWER JACK STUDS
400 mm
ON CENTER

BEST COPY AVAILABLE

TITLE: Joining with Silver Solder

DESCRIPTION:

When metals are heated the crystals within the metals move apart, creating microscropic spaces. The idea of soldering is to use an alloy that will flow when there are gaps between the crystals. This alloy floods into the spaces and is bonded there as the two metals contract.

SCIENCE CONCEPTS:

1. Soldering is a process used when bonding two pieces of metal together: you are not melting the metals that are to be joined, you are using a third material to bond them together.

2. Silver Soldering is also considered hard soldering because the melting point of silver solder is approximately 1100°F to 1300°F (593° C - 704°C).

3. The advantages of using silver alloy soldering are:

   A. If the metals that are going to be joined together are used in heating process the joint will hold due to the high melting point of the silver alloys.

   B. If the joint is subjected at all to any kind of motion whereby the one metal making up the joint vibrates independantly from the other metal piece making up the joint, the silver alloy in the joints will hold because of the high melting temperature of the silver alloy. This is a key factor because the movement will create friction thus increasing the temperature of the joint.

4. The pieces being silver soldered together must be fitted very tightly together because the silver flows out very thinly and freely. When the joint is tight and the surfaces to be joined are clean and the proper flux is used, a good strong bond will be obtained. Number five explains this.

5. The concept of cohesive forces is used to explain why silver soldered is used to bond two metal pieces together. The molecules of silver alloy have a greater affinity for the metal pieces than they do for themselves so when the solder cools it "sticks" to the metal pieces.

6. Capillary action: When the solder melts it flows into the joints by capillary action (solid metal attracts the metal filler.)

7. Flow of Heat: Heat flows from hot to cold. That sucks the solder into the gap where it wets both metal surfaces.

TITLE: Joining with Silver Solder

DESCRIPTION: When metal is heated the crystals of which it is made move apart, creating microscopic spaces. The idea of soldering is to use an alloy that will flow when there are gaps between the crystals. This alloy floods into the spaces and is bonded there as the two metals contract.

MATH CONCEPTS:

1. Percentages. Silver solder is an alloy of various elements.

2. The amount of zinc in silver solder controls its melting points. Overheating may cause the zinc to go off in a vapor. Each time solder is heated its melting point is raised.

3. Different Grades of Silver Solder and their proportions,
   A. "I T" 80% Ag 16% Cu and 4% Zn MP 809 °C -1490°F
   B. Hard 76% Ag 21% Cu and 3% Zn MP 773°C - 1425°F
   C. Medium 70% Ag 20% Cu and 10% Zn MP 747°C - 1390°F
   D. Easy 60% Ag 25% Cu and 15% Zn MP 711°C - 1325°F
   E. Easy Flo 50% Ag 15% Cu and 15% Zn 20% Cd MP 681°C - 1270°F
   (Note: Ag = silver, Cu= copper, Zn = Zinc, Cd = cadmium, MP = melting point)

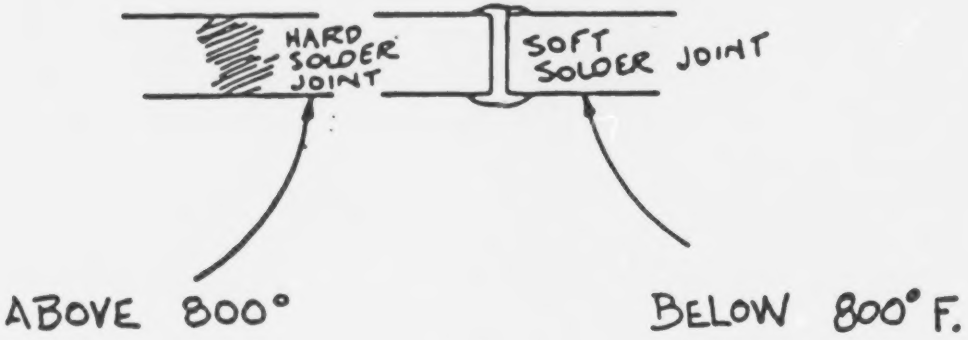
4. Temperature conversion formulas:
   A. $C = \frac{5}{9}(F-32)$
   B. $F = \frac{9}{5}C + 32$

5. Solving algebraic formulas. Stress in on substitution and order of operations.

6. Specific facts on silver: The melting point is about 960.5 °C or 1761°F. The hardness is 2-2 1/2. The specific gravity is 10.5. The atomic weight is 107.88.

7. Ratios: The ratio of the weight of a body to the weight of an equal volume of water (relative density) is called the specific gravity.

JOINING WITH SILVER SOLDER

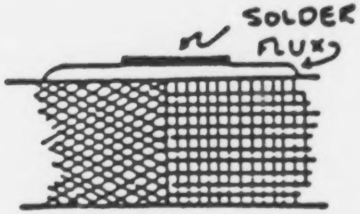

HARD SOLDER JOINT
SOFT SOLDER JOINT
ABOVE 800°
BELOW 800° F.

name	Ag	Cu	Zn	Cd	melt. pt.	
"IT"	80	16	4		809°	1490°
HARD	76	21	3		773°	1425°
MEDIUM	70	20	10		747°	1390°
EASY	60	25	15		711°	1325°
EASY-FLO	50	15	15	20	681°	1270°

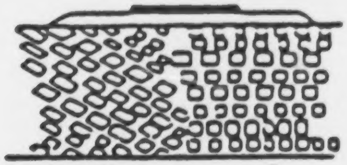
SILVER SOLDER

JOINING WITH SILVER SOLDER

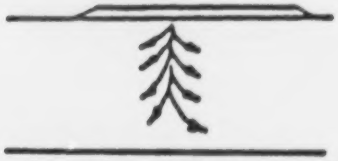
Recrystallization and Capiliary Action


SOLDER
FLUX

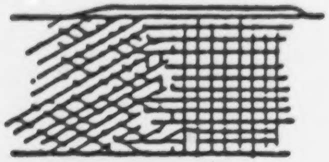
CRYSTALS PACKED TIGHT.



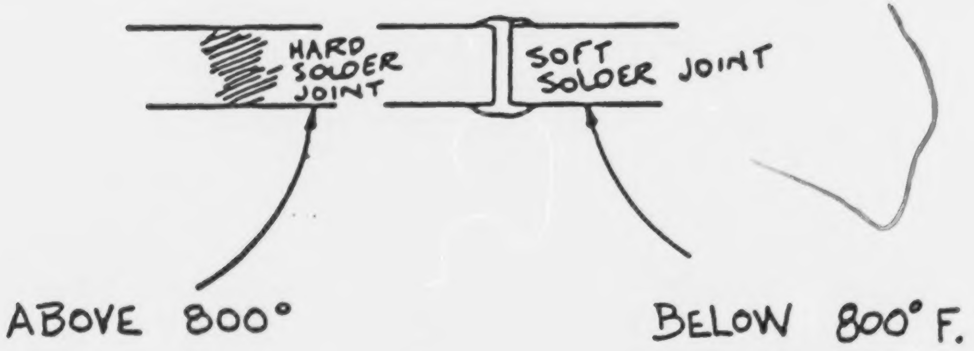
CRYSTALS MOVE APART, METAL HAS EXPANDED.



SOLDER MELTS AND IS DRAWN INTO SPACES BY CAPILLARY ACTION.



WHEN COOLED. SEAM IS INVISIBLE.


HARD SOLDER JOINT
SOFT SOLDER JOINT
ABOVE 800°
BELOW 800° F.

Title: Miter Joints

Category: Construction

Description:

The face grain of wood is more attractive than the end grain. When a joint must be asthetically pleasing, miter joints can be used to present a smooth, continuous surface. Miter joints are a type of butt joint that can be used in objects with various numbers of sides. A formula can be used to determine the cutting angle. The components of mitered pieces are cut with a saw using a miter guage. The parts are then placed in a miter vise and glued. Since miter joints are notoriously weak, it is common practice to reinforce the joint with dowels, feathers, splines, braces, and/or metal fasteners, especially if the joint is to bear a significant load.

Title: Miter Joints

Category: Construction

Science Concepts:

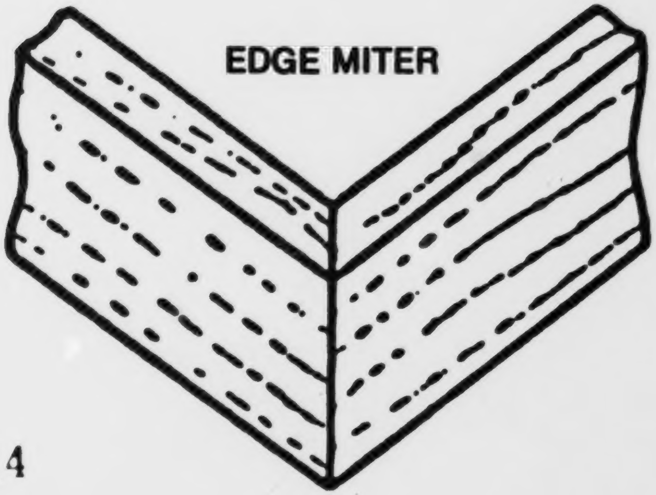
1. The strength of the miter joint depends on several variables, including:
   - A - Accuracy of cut
   - B - Adhesive
   - C - Reinforcement (with dowel, feather, spline, brace, metal fasteners).
   - D - Moisture content of wood
   - E - Sealer
   - F - Weight of materials and load
2. Adhesion is the mechanical or molecular affinity of one material to another.
3. Weight is a force caused by gravity acting upon the mass of an object.
4. Stress is an applied force or system of forces that has a tendancy to strain or deform.
   - A - Expansion stress involves pushing from the inside, or pulling from the outside.
   - B - Tension stress involves squeeze
   - C - Sway stress involves lateral movement
   - D - Rotational stress, involves circular and cantilever systems
5. Warp is any variation from a true or plane surface.

Math Concepts:

1. Angle Measures
2. Reading Tables/Scales
3. Measuring
4. Adding/Subtracting Fractions
   - A. Common Denominator
   - B. Simplifying Fractions
   - C. Changing from Improper to Proper
5. Perimeter of Polygons

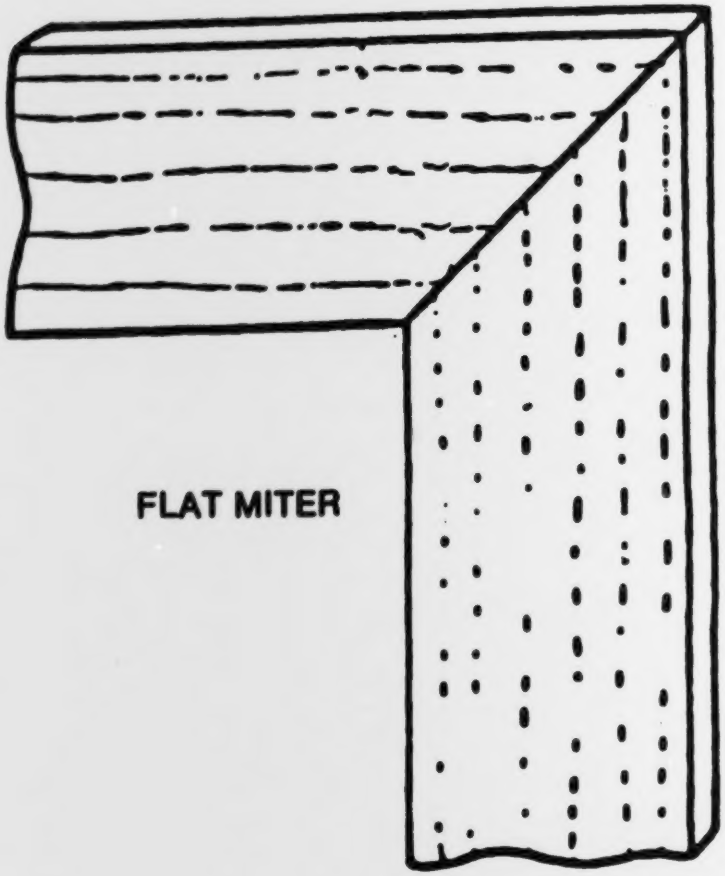
MITER JOINTS

- AN ANGLED BUTT JOINT THAT PRESENTS A SMOOTH CONTINUOUS GRAIN PATTERN.



EDGE MITER

114

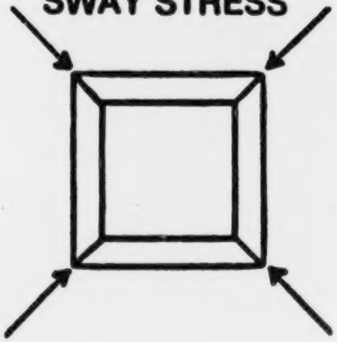


FLAT MITER

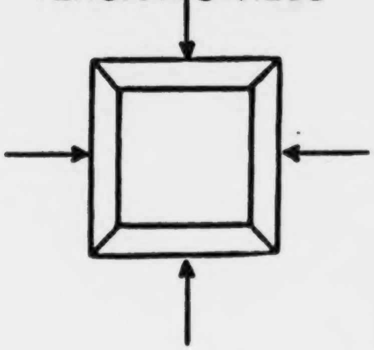
115

MITER JOINTS

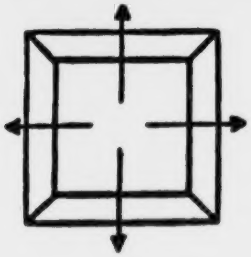
SWAY STRESS



TENSION STRESS

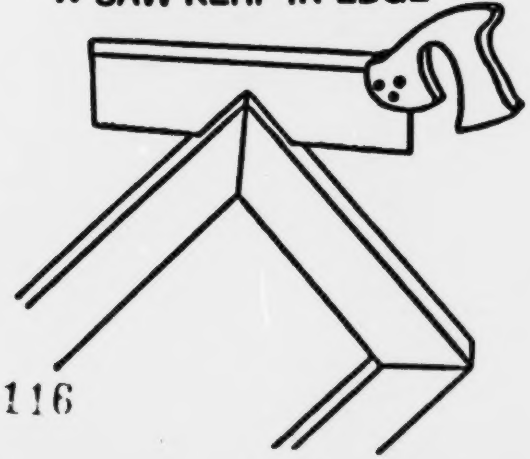


EXPANSION STRESS

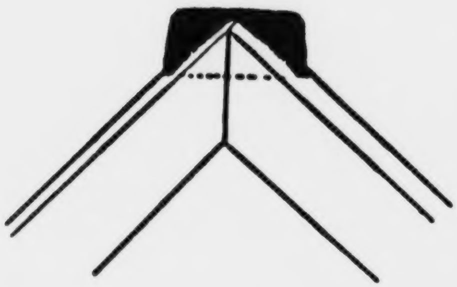


REINFORCEMENT

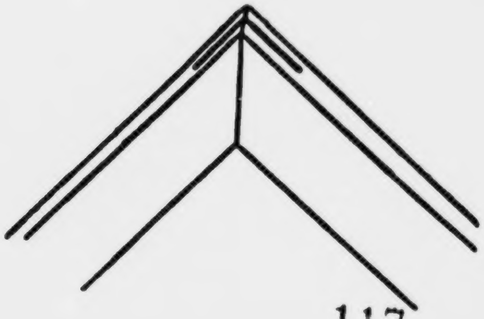
1. SAW KERF IN EDGE



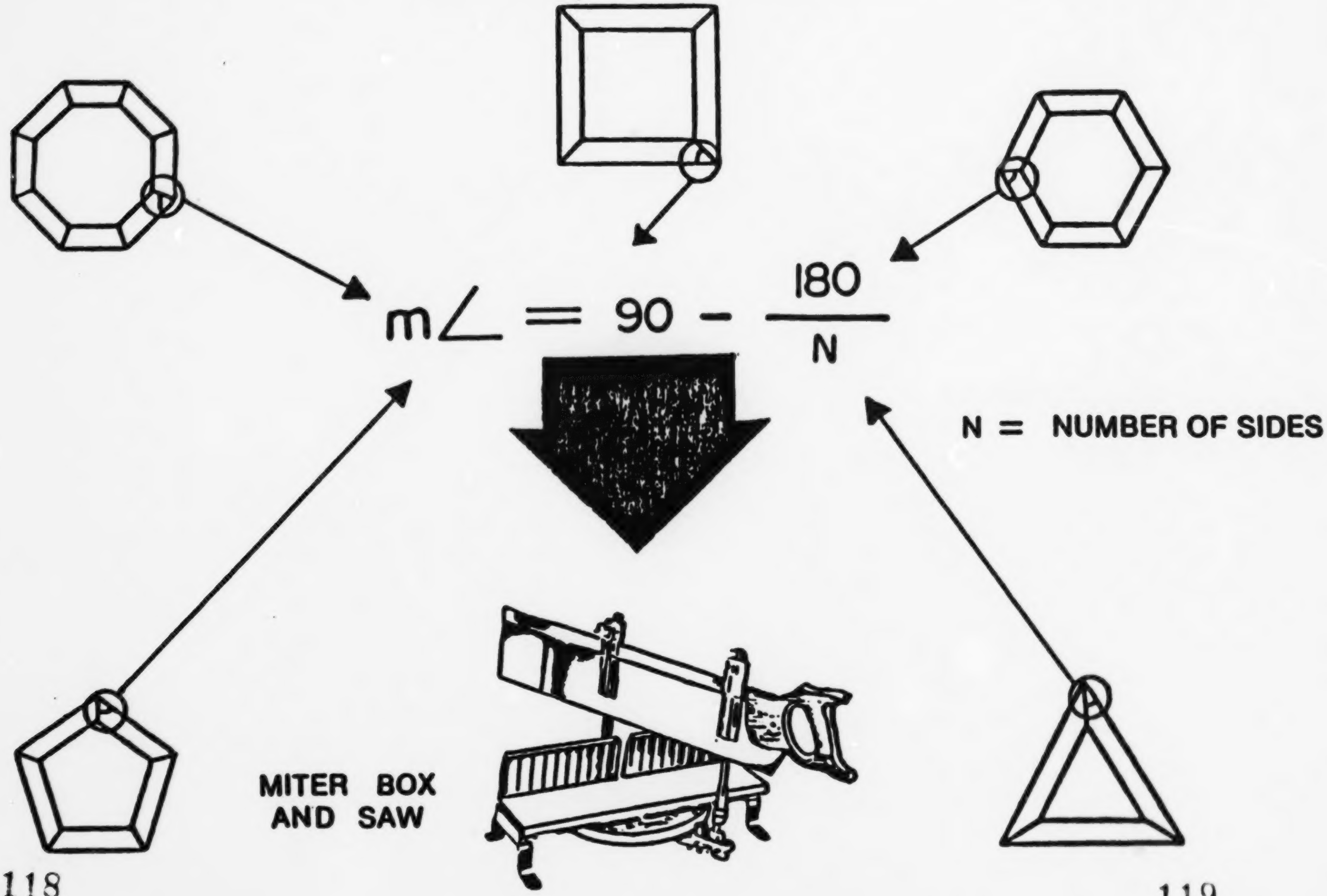
2. GLUE WOOD VENEER IN KERF



3. TRIM EDGE



MITER JOINTS



$$m\angle = 90 - \frac{180}{N}$$

N = NUMBER OF SIDES

MITER BOX
AND SAW

TITLE: Nailing Technology - Holding Power

DESCRIPTION:

This transparency on nail holding power deals with math and science concepts that show that holding power is a function of a nail's diameter, its driven length, the grain direction and density of the wood into which it is driven.

SCIENCE CONCEPTS:

1. Common nails are large, flat-headed wire nails of standard guage wire for any given length. Usually these nails are plain but may have spiral grooves or ringed grooves which help the nail adhere to a surface.

2. Factors that affect the holding power of nails are:

   a. As the nail length increases, the holding power increases.
   b. As the diameter of the nail increases, the holding power increases.
   c. The denser the material into which the nail is driven, the greater the holding power. (Density is weight per unit volume - g/cm or lbs./in.).
   d. A smooth nail has less holding power than a galvanized or grooved nail.
   e. Dry wood will hold a nail better than damp wood. When damp wood dries, it shrinks, and the nail might pop.
   f. A sharper point on a nail will have greater holding power.
   g. As a sharper pointed nail is driven into the wood, many cells in the path are broken, and severed ends are bent and compressed in the direction of the driving. The tendenacy of cell ends to recover causes them to press against the nail surface resulting in resistance to withdrawal or greater holding power.
   h. Driving force affects holding power. A moderately slow blow will hold best.
   i. Greatest holding power is obtained when a nail is driven at a right angle to the wood fibers.

3. A nail with a blunt point has less tendency to cause splitting because a plug of compressed wood structure is torn loose and pushed ahead of the point rather than being pushed aside to start a split. However, greater cell damage reduces holding power.

4. The common diamond point nail seems to give the greatest holding power with the least splitting.

5. The best holding power develops when the nail holes are prebored.

6. Prebored holes ranging from 60% shank diameter for low-density woods to 85% shank diameter for high-density woods give the maximum holding power.

7. Holding power of nails diminishes over a long period of time after installation.

8. Extreme moisture variation will decrease long term holding power.

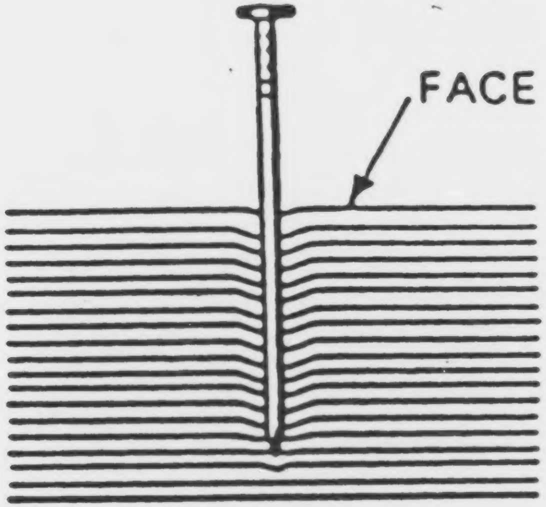
Math Concepts:

1. Holding power and nail size. Holding power is directly affected by nail size. Length of nail is designated in pennies, abbreviated as 'd'. This designation is an old English term which may have originally have designated the cost in pennies for a hundred nails. The diameter of the shank and the size of the head vary with the length of the nail and the type of nail. Common nails increase in length by 1/4 inch from 2d to 16d. They increase by 1/2 inch from 16d to 60d.

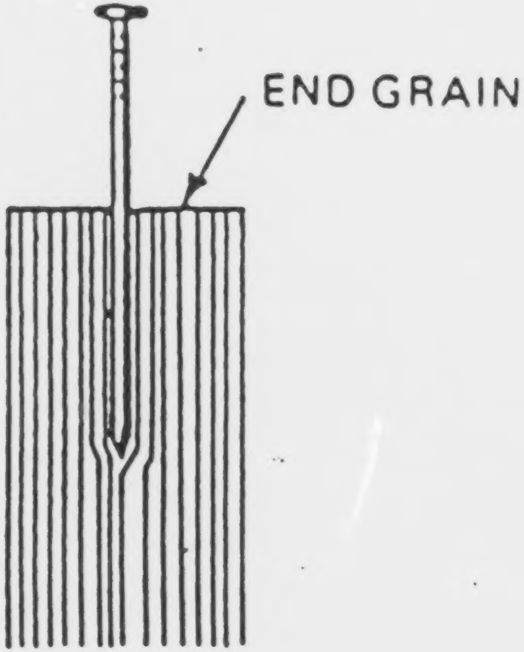
2. Holding power and nail withdrawal.
    a. A general formula for direct nail withdrawal (L) of a common nail immediately after driving, is:
    p = 7,850 x G x D x L, where p = maximum withdrawal (load, in pounds)
    G = the specific gravity of the wood.
    D = Nail diameter in inches.
    b. Under these conditions, direct withdrawal varies directly with the diameter and length of the nail; the greater the holding power. Therefore, we can say that the holding power of a nail is a function of its diameter (D), its driven length (L) and the grain direction and density of the wood into which it is driven.
    c. The maximum holding power results when nail holes are prebored. While most woodworkers accept the idea of installing woodscrews in prebored nail holes to prevent splitting and to maximize holding power, they seldom consider preboring nail holes. Pilot holes range from 60% of nail shank diameter for low-density woods. This gives maximum holding power.

    1. Percentage. Percent is a form of fractions, where a whole is divided into parts. 60% means 60 parts out of 100 parts are being used. 85% is the greater percentage with 85 parts being used out of 100 parts.

NAILING TECHNOLOGY
HOLDING POWER



BENT FIBERS RESIST
WITHDRAWAL



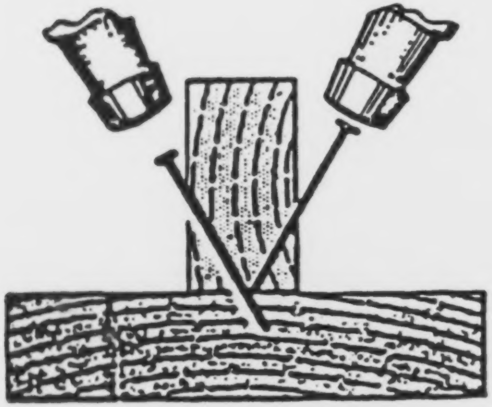
FIBERS DO NOT HOLD NAIL FIRMLY
SPLITTING POSSIBLE

THE HOLDING POWER OF A NAIL IS A FUNCTION OF ITS DIAMETER, ITS DRIVEN LENGTH. THE GRAIN DIRECTION, AND DENSITY OF THE WOOD INTO WHICH IT IS DRIVEN.

NAILING TECHNOLOGY
HOLDING POWER

THE HOLDING POWER OF A NAIL IS A FUNCTION OF ITS DIAMETER, ITS DRIVEN LENGTH. THE GRAIN DIRECTION, AND DENSITY OF THE WOOD INTO WHICH IT IS DRIVEN.

TOENAILING



$$\text{WOOD DENSITY} = \frac{\text{lbs}}{\text{in}^3} \text{ or } \frac{\text{grams}}{\text{cm}^3}$$

TITLE: Nailing Technology-Wood Splitting

DESCRIPTION:

This transparency presents factors which prevent splitting of wood.

SCIENCE CONCEPTS:

1. The wedge is a movable inclined plane. Axes, chisels, knives, nails, and pins are common examples of wedges. As the sharp edge of each of these is pushed or hammered into an object, the sides of the wedge exert great force on it, tending to split or push it apart.

2. Because of the large part friction plays in the operation of the wedge, it is difficult to determine its exact mechanical advantage.

3. When nails are driven into wood, a force is exerted on the wood fibers which may bend, break, or split. Bent fibers tend to return to their normal position, thus pressing against the nail and wedging and gripping it lightly.

4. A sharply pointed nail acts as a wedge and may split the wood when driven in. Therefore, a slightly blunted nail will not split the wood or displace fibers but will crush the fibers. Some reduction in holding power will result.

5. When a nail is driven into a side-grain surface, longitudingal cell structure is separated or split apart and also compressed ahead of the point depending on the sharpness of the point. As the nail progresses, many cells in the path are broken; and the severed ends are bent and compressed in the direction of the driving. The tendency of the cell ends to recover causes then to press against the nail surface which results in greater holding power.

6. The density of wood also effects the nail choice. Dense woods such as cherry, maple, and popular would need a blunt nail. Less dense wood such as basswood, pine, or balsa would not require as blunt a tip on the nail to prevent splitting.

7. A nail with a blunt point has less tendency to cause splitting because a plug of compressed wood structure is torn loose and pushed ahead of the point, rather than being pushed aside to start a split.

8. Density (weight per unit volume or $\text{density} = \frac{\text{mass}}{\text{weight}}$) is

the single most important indicator of strength in wood and may predict such characteristics as hardness.

9. The density of wood is not directly related to the terms hardwood and softwood. The term hardwood is used for wood from trees that lose their leaves (deciduous trees) while the term softwood is used for wood from trees that do not lose their leaves (evergreen or coniferous trees).

MATH CONCEPTS:

1. Proportions - statement that two ratios are equal to each other. Proportion is written $\frac{A}{B} = \frac{C}{D}$ and is read A is as to B as C is to D. A and D are the extremes and B and C are the means. $A \times D = B \times C$. Therefore we say product of the means equals the product of the extremes.

2. Definite rules have been formulated by which to determine the size of nail to be used in proportion to the thickness of the board, so as to prevent splitting.

a. In timber of medium density the penny of the nail should not be greater than the thickness in eights of an inch of the board into which the nail is being driven.

b. In less dense woods the nails maybe one penny larger.

c. In high density woods nails should be one penny smaller.

3. Proportion is used in the spacing of nails to prevent splitting.

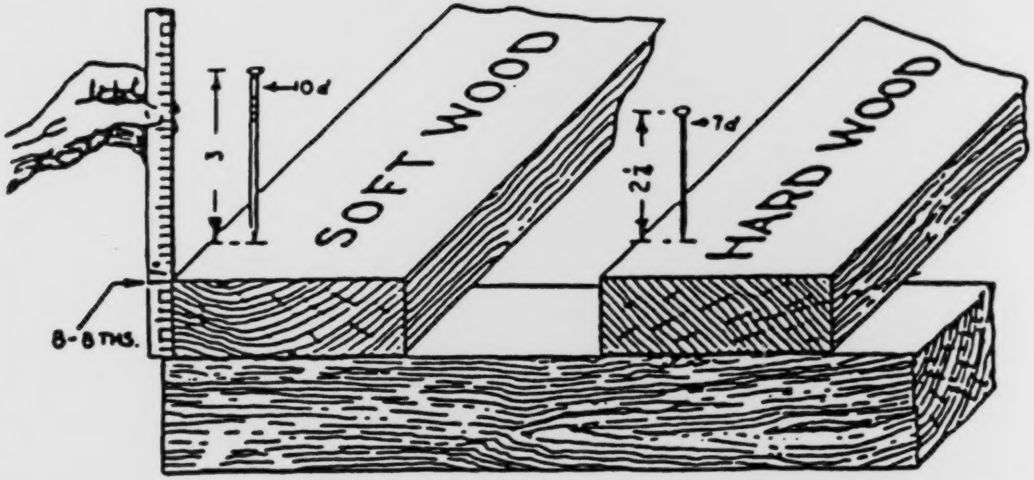
a. Six penny or smaller nails holding in the side grain should be driven about two inches apart, and the same size nails in end grain should be driven about one and three-quarter inch for each additional penny in size. This may seem too close, but it is only about two-thirds the number that can be used in a board before excessive splitting takes place.

4. Wood density and proper nail size control splitting. Wood density equals the Mass of the wood divided by the Volume.

$$\text{Density (D)} = \frac{\text{Mass (M)}}{\text{Volume (V)}}$$

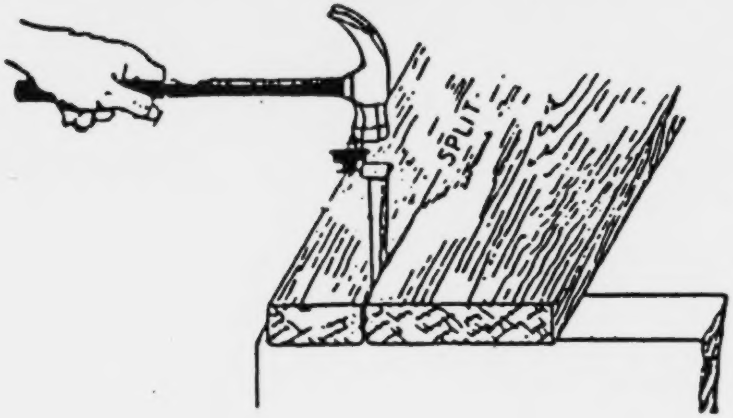
NAILING TECHNOLOGY
WOOD SPLITTING

$$\text{WOOD DENSITY} = \frac{\text{lbs}}{\text{in}^3} \text{ or } \frac{\text{grams}}{\text{cm}^3}$$


10d
3
SOFT WOOD
7d
2¼
HARD WOOD
8-8 THS.

Use the proper proportion to prevent splitting ➔ $\dfrac{\text{Size of nail}}{\text{Board thickness}}$

NAILING TECHNOLOGY
WOOD SPLITTING



FACTORS AFFECTING SPLITTING

DISTANCE NAIL IS FROM END OF BOARD

DIAMETER OF NAIL

DENSITY OF BOARD

DRILLING A PILOT HOLE

BLUNTING END OF NAIL

WOOD DENSITY = $\frac{\text{lbs}}{\text{in}^3}$ or $\frac{\text{grams}}{\text{cm}^3}$

Title: Roof Framing

Category: Construction

Science Concepts:

1. A force is an action which produces motion, pressure, or tension.

   F = Ma

   F = Force

   M = Mass

   a = acceleration

2. Forces may be internal (parts within the system exert force upon one another).

3. Forces may be external (they originate outside the system).

   $\text{Stress} = \frac{\text{Force}}{\text{Area}}$

4. The three properties or elements of force are:

   A. Magnitude - the magnitude of a force is its number of units of energy.

   B. Direction - direction in which a force tends to move an object.

   C. Line Of Action - path along which a force acts.

5. Every body of matter has a center of gravity which is the effective location of the body mass in so far as external forces are concerned.

6. Statics is the science which deals with forces of equilibrium.

7. Equilibrium results when forces whose combined effect produces no motion or change in state of rest. (Equal opposing forces result in no movement).

8. Newton's First Law of Motion - an object remains in a state of rest unless a force causes it to move and an object continues in motion along a straight line unless a force stops it or causes the object to change direction.

9. Newton's Third Law of Motion - for every force, there is an equal and opposite force. (The type of roof used depends upon the the wind and snow. The weight applied to a roof is an important factor).

10. P.S.F. = Pounds per square foot.

Title: Roof Framing

Category: Construction

Related Mathematical Concepts:

1). Knowledge of some simple geometric figures: triangles (isosceles, and right); parallelograms; polygons.

2). Ability to read carpenter's square which requires knowledge of inches and fractional parts of an inch.

3). Ability to measure angles (use of protractor to pratice).

4). Ability to read tables on a framing square to find length of rafters.

Run x no. from table on square = rafter length must convert decimals to fractions.

Multiply fractions (mixed nos). and multiply decimals

Subtract fractions and add fractions

5). Understanding of ratio and scale.

6). Know formulas for slope and pitch.

$\text{Slope} = \frac{\text{rise}}{\text{run}}$ $\qquad$ $\text{Pitch} = \frac{\text{rise}}{2 \times \text{run}}$ or $\frac{\text{rise}}{\text{span}}$

7). Knowledge and use of Pythagorean theorem.

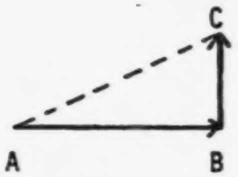
$A^2 + b^2 = c^2$

8). Use of vectors to solve stress problems.

Solve vectors graphically be parallelogram and polygon methods.

Solve vectors analytically by application of laws of trigonometric ratios and application of algebraic laws.

9).



Addition of vectors

$\overrightarrow{AB} + \overrightarrow{BC} = \overrightarrow{AC}$

$\overrightarrow{AC}$ is the resultant vector and can replace $\overrightarrow{AB}$ and $\overrightarrow{AC}$

Title: Roof Framing

Category: Construction

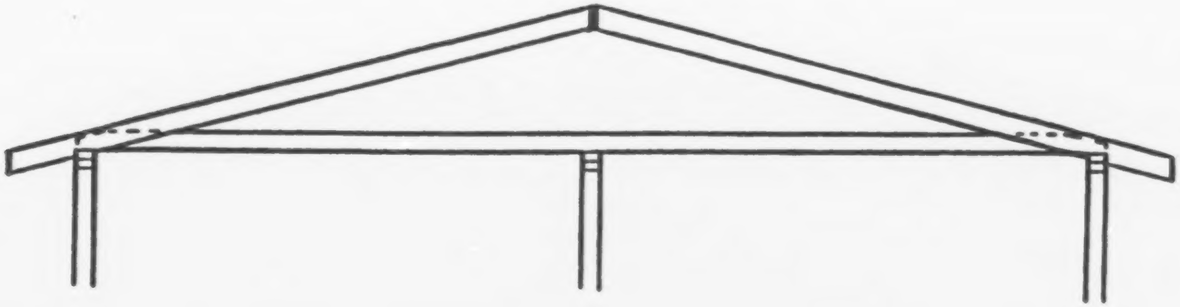
Related Mathematical Concepts:

10). Definitions

Vectors - graphical representations of a quantity of force which is drawn to scale to indicate magnitude, direction, sense, and point of application.

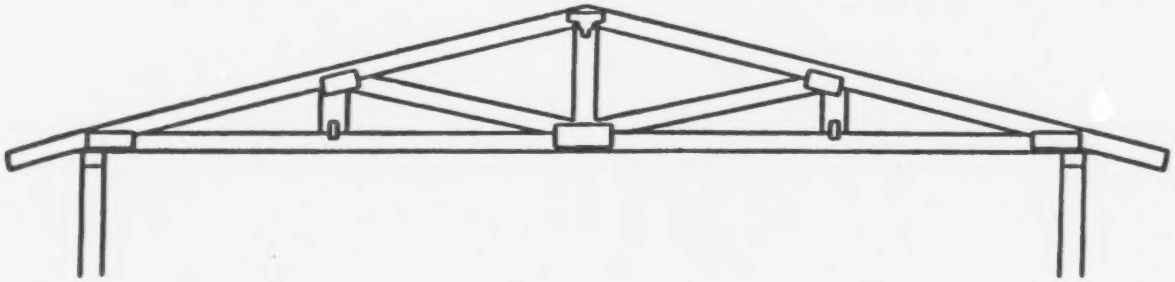
11). Resultant - a single force that can replace all the forces of a force system and have the same effect as the combined forces.

ROOF FRAMING



RAFTER LENGTH = RUN OF THE RAFTER TIMES X.

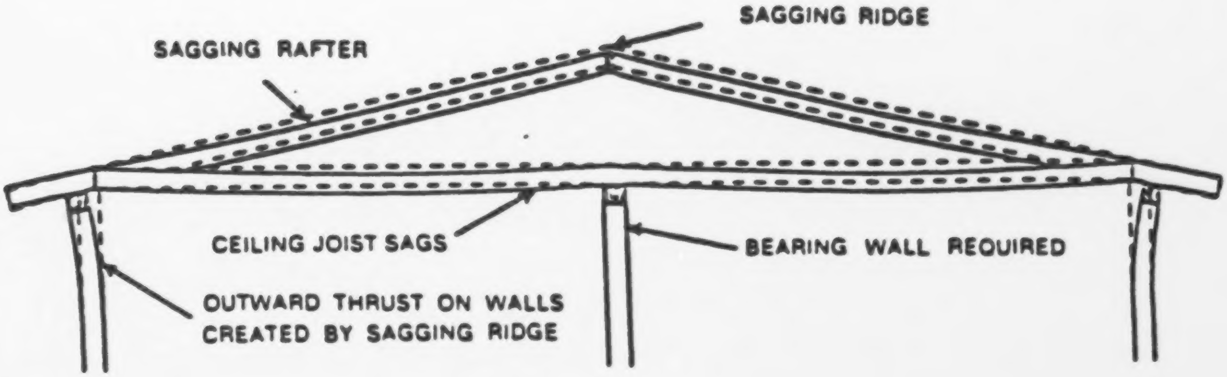
(WHERE X IS THE VALUE OBTAINED FROM THE FRAMING SQUARE FOR THE RISE)



FORCE: AN ACTION WHICH PRODUCES MOTION, PRESSURE, TENSION, OR COMPRESSION.

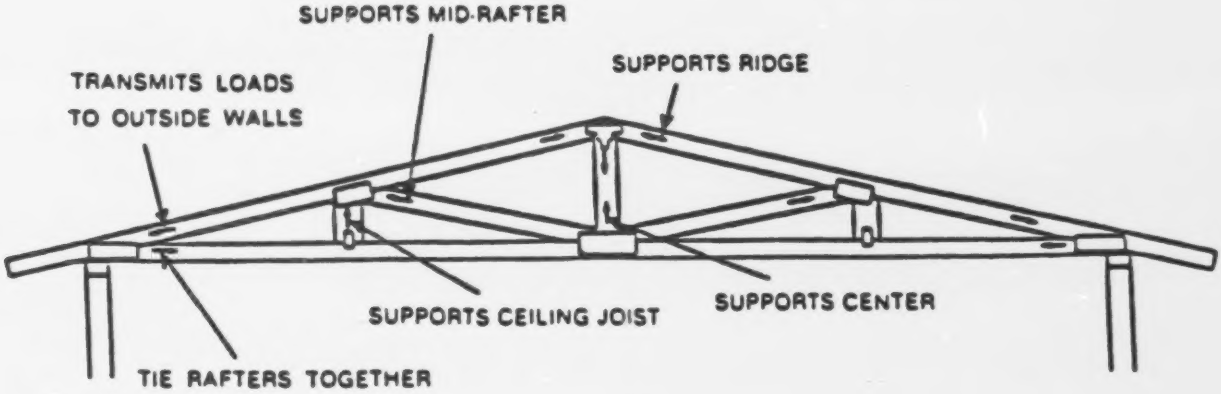
ROOF FRAMING

DISADVANTAGES



SAGGING RIDGE
SAGGING RAFTER
CEILING JOIST SAGS
BEARING WALL REQUIRED
OUTWARD THRUST ON WALLS
CREATED BY SAGGING RIDGE

ADVANTAGES



SUPPORTS MID-RAFTER
SUPPORTS RIDGE
TRANSMITS LOADS
TO OUTSIDE WALLS
SUPPORTS CEILING JOIST
SUPPORTS CENTER
TIE RAFTERS TOGETHER

TITLE: Screwdriver

DISCRIPTION:

The Screwdriver is a simple machine using the concept of the lever or wheel and axle for its operation.

SCIENCE CONCEPTS

1. Less effort is required to overcome a force when using a tool than when a tool is not used.

2. Although tools allow us to use less effort to overcome a force, they do not save us work.

3. When using a tool, the effort must be applied over a longer distance

4. The lever has basically three parts:
   a. Resistance - force to be overcome
   b. Effort ÷ force needed to overcome the resistance.
   c. fulcrum - pivot point of a lever.

5. Levers are divided into three classes depending upon the position of its three parts:

   a. first class lever with fulcrum in center
   b. second class lever with resistance in center
   c. third class lever with effort in center

6. The screwdriver is a first class lever.

TITLE: Screwdriver

DISCRIPTION: The Screwdriver is a simple machine using the concept of the lever or wheel and axle for its operation.

MATH CONCEPTS:

1. Increasing the diameter of the handle, reduces the effort required to drive the screw.

2. Formula for finding work, force, or distance.

   Work = Force X Distance

   $W = F \times D$

   $F = \frac{W}{D}$

   $D = \frac{W}{F}$

   A. Work can be measured in joules or pounds.
   B. Force can be measured in Newtons or pounds.
   C. Distance can be measured in meters or feet.
   D. Joules is defined as a unit of work measured in Newton - meters (N - M)

3. Some words needed in order to understand the lever are:

   A. Effort - The effort is the force applied to a machine. It may be a push, pull, or twist. In the figures the letter E shows the location and direction of the effort.

   B. Resistance - The resistance works against the effort. It may be a weight or object to be moved. The resistance is shown by the letter R and a weight.

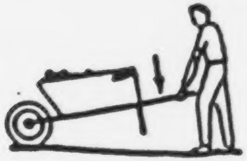
   C. Fulcrum - The fulcrum is the pivot point on which a lever turns. The fulcrum is shown by the letter. F.

   D. Mechanical advantage - Mechanical advantage is the ratio of the effort to the resistance. Mechanical advantage is often called leverage, even though a lever may not be the machine in use. Mechanical advantage may be abbreviated M.A.

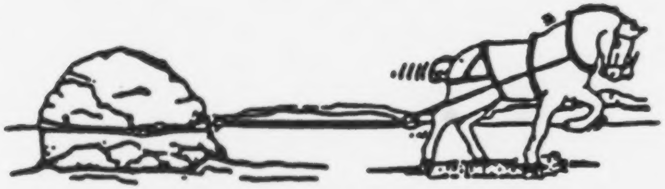
   E. Formula for finding mechanical advantage is

   $MA = \frac{R}{E}$

THE SCREWDRIVER

a working  lever

WORK = FORCE (pounds) x DISTANCE (feet)



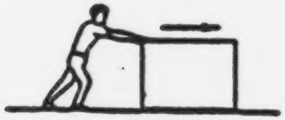
Work is the amount of force exerted on an object times the distance the object moves.

force

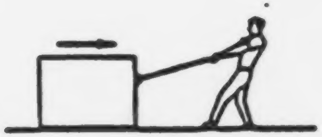
$$F = \frac{W}{D}$$

Force is a push, pull, or twist of any kind in any direction.

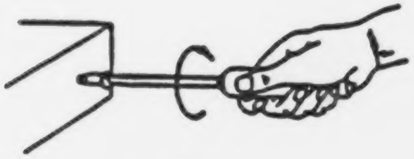
$$W = F \times D$$



Push



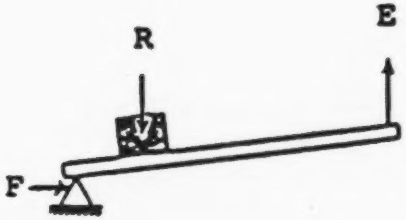
Pull



Twist

parts

of a lever

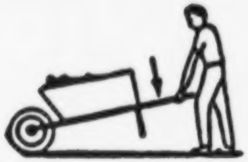


F = fulcrum- the point about which the lever pivots.

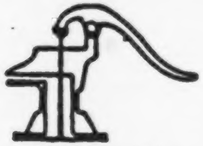
E = effort- the force applied to overcome the resistance.

R = resistance- the weight or object to be moved.

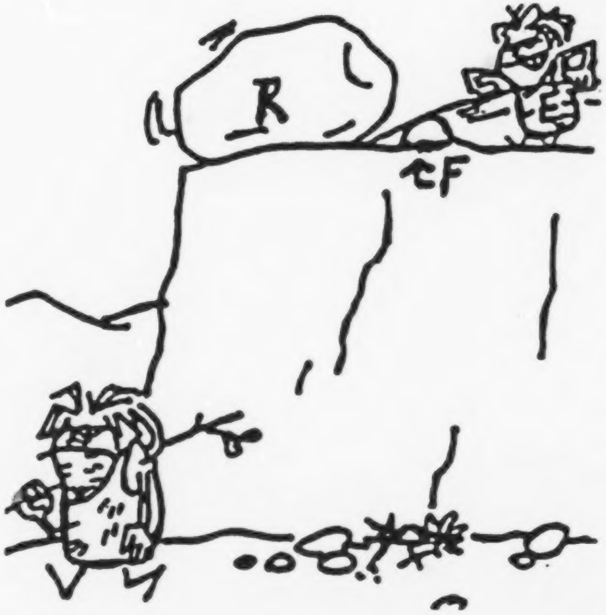
THE SCREWDRIVER

a working  lever

Definition: A lever is a rigid bar that is free to pivot about a fixed point.

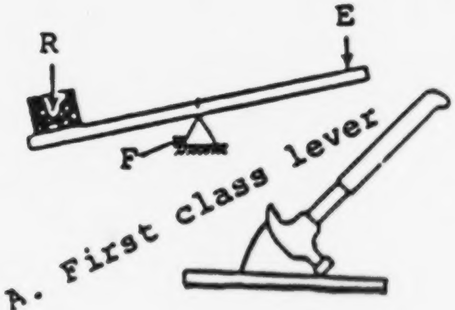


pumphandle

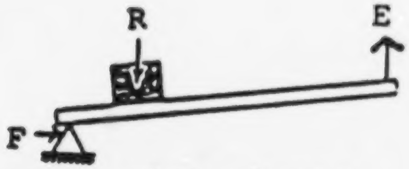


classes of levers

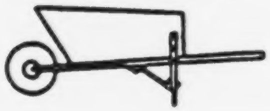
Depends on the position of the fulcrum, effort, and resistance.



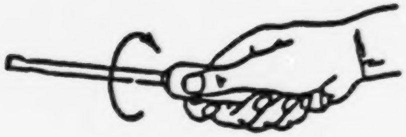
A. First class lever

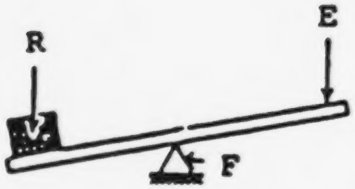


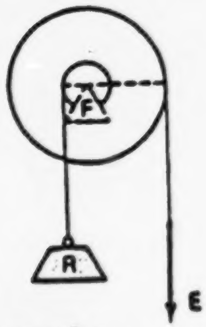
B. Second class lever



application to screwdriver

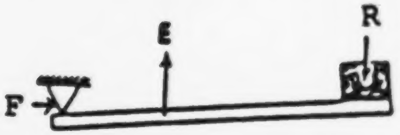




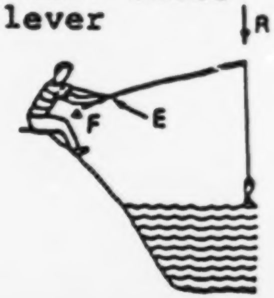


Principle of Operation:

The screwdriver is essentially a circular lever capable of rotating about its fulcrum.



C. Third class lever



Title: Steel

Science Concepts:

1. Steel is an alloy of iron and carbon.

2. An alloy is a metal consisting of 2 or more metals.

3. Iron ore, coke, limestone and compressed air are used to make steel.

4. The amount of carbon in steel determines its physical properties such as tensile strength, hardness, ductility, and melting point.

5. The quantity of carbon is 1.5% or less.

6. Tensile strength is the ability of steel to resist being pulled apart.

7. Hardness is the ability to resist scratchine and penetration.

8. Ductility is the stretching ability of metals.

9. The melting point is the temperature at which the substance becomes a liquid.

10. The amount of carbon in steel determines its classification as low-C, high-C and medium-C.

11. Low carbon steel has a tensile strength of 50,000 to 70,000 p.s.i. and contains 0.05 to 0.3% carbon.

12. Medium carbon steel has a tensile strength of 70,000 to 100,000 p.s.i. and contains 0.3 to 0.6% carbon.

13. High carbon steel has a tensile strength of 100,000 or more p.s.i. and contains 0.6 to 1.5% carbon.

14. The abbreviation p.s.i. means pounds per square inch.

15. Low carbon steel is used to make nails, wire, bolts, rivets, chains.

16. Medium carbon steel is used to make automobile springs, axles, gears.

17. High carbon steel is used to make files, drill bits, metal cutting tools, and bearings.

18. The higher the carbon content, the greater tensile strength, hardness, and brittleness, the lower the ductility and melting point.

19. The higher the carbon content, the stronger the steel.

20. After 1.5% carbon the alloy is very brittle and only suited for casting.

Math Concepts

1. Low-carbon steel has a percentage of 0.05% to 0.3% carbon and may be referred to as mild steel.

2. Low-carbon steel has a tensile strength in the range of 51,000 to 70,00 p.s.i.

3. The percentage of carbon in medium-carbon steel ranges from 0.3% to 0.6%.

4. The steel's tensile strength varies with the amount of carbon from 70,000 to 95,000 p.s.is in medium-carbon steel.

5. The carbon content of high-carbon steel ranges from 0.6% to 1.5%.

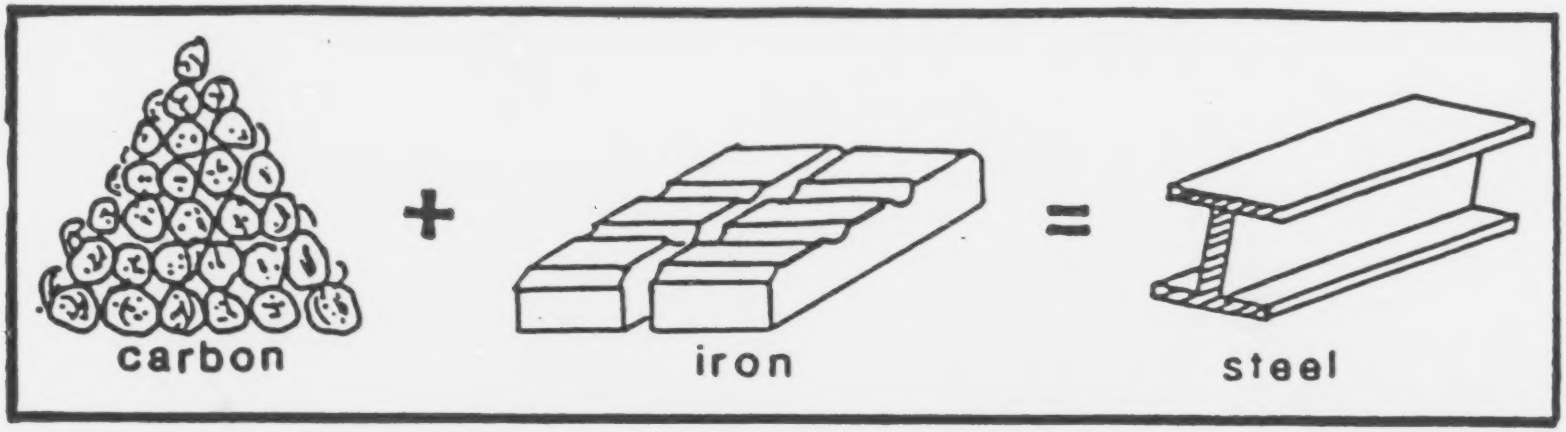
6. The steel's tensile strength in high-carbon steel ranges from 95,000 and up p.s.i.

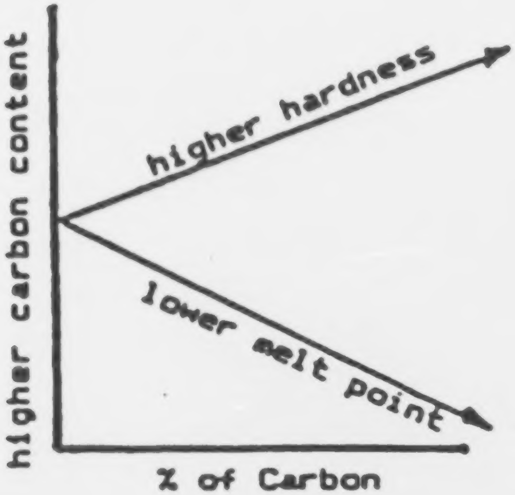
7. The tensile test reveals a great amount of information about metals. Common metals have very high tensile strengths. A piece of hot rolled steel bar (c 1010) one inch square will lift a load of up to 25 tons before it will fail. This calculation is made by taking the tensile strength of the carbon steel which is 51,000 pounds per square inch (p.s.i.), and the number of square inches is 1. There are 2,000 pounds in a ton (T); therefore, 51,000 divided by 2,000 equals approximately 25 T. 1 (sq. in.0 x 51,000 (p.s.i.) = 51,000 lbs.

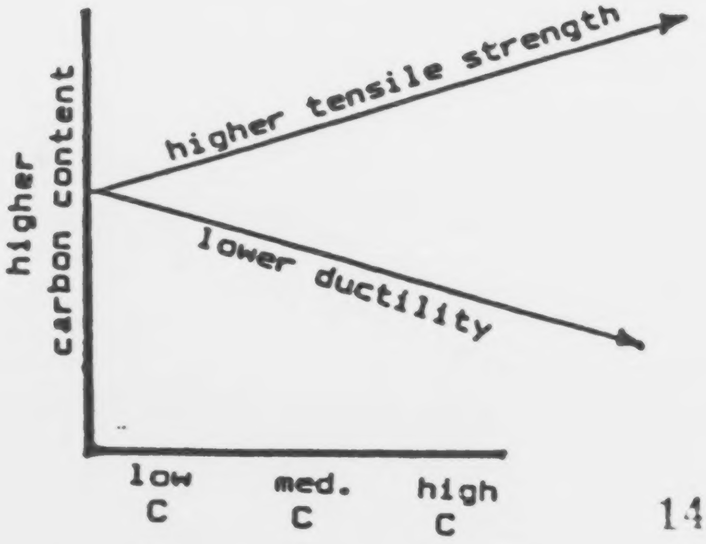
STEEL

STEEL IS AN ALLOY

- An ALLOY is a metal that has more than one component -


carbon
+
iron
=
steel

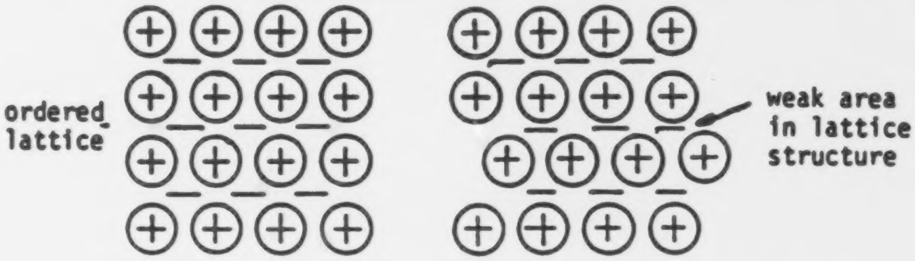

higher carbon content
higher hardness
lower melt point
% of Carbon


higher carbon content
higher tensile strength
lower ductility
low C
med. C
high C

TITLE: Tensile Strength of Steel

DESCRIPTION:

The tensile strength of metal is a function of its crystal lattice structure. The more orderly the structure, the stronger the bonds among the outer valence electrons of the atoms forming the crystal. A less ordered arrangement of atoms forms weak spots in the lattice.



The electrons are shared in a "fluid" among the nuclei of the iron and carbon atoms in the lattice.

SCIENCE CONCEPTS

1. Increasing the carbon raises the tensile strength by "perfecting" the lattices.
2. Low carbon steel is more easily deformed (ductile) but lacks tensile strength compared to steel with higher carbon content.
3. Atoms bond by electrostatic forces holding negative electrons to positive nuclei.
4. Electrons are shared among the atoms in a crystal, thus forming covalent bonds.

TITLE: Tensile Strength of Steel

DESCRIPTION:

The purpose of this lesson is to test tensile strengths of steel and to calculate tensile stresses of steel given the force applied and the dimensions of the steel. After testing tensile strengths the student will be required to find the percent of elongation of the steel using the original length and the length of the deformed piece of steel.

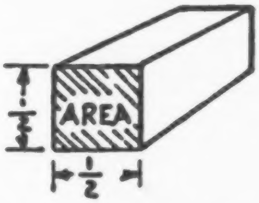
MATH CONCEPTS:

1.) Area:

Area of a rectangular bar:

Area = length x width

Example: $\frac{1''}{2} \times \frac{1''}{2}$ bar.

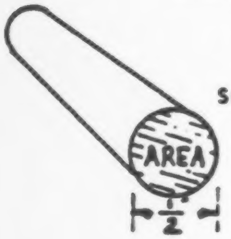


Area = $\frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$ sq. in. (multiply numerators then multiply denominators)

Area of a rod:

Area = π x radius x radius (where π = 3.14)

Example: $\frac{1''}{2}$ diameter rod.



diameter = 2 x radius or $\frac{1}{2}$ x diameter = radius

so, radius = $\frac{1}{2} \times \frac{1''}{2} = \frac{1''}{4}$

Area = $\pi \times \frac{1''}{4} \times \frac{1''}{4}$

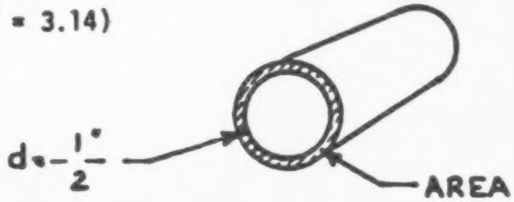
Area = $3.14 \times \frac{1}{16} = \frac{3.14}{1} \times \frac{1}{16} = \frac{3.14}{16} = 0.20$ sq. in.

Area of a tube:

Area = Area of large circle - Area of inside circle

Area = (π x radius_1 x radius_1) - (π x radius_2 x radius_2)

(where π = 3.14)



MATH CONCEPTS cont.

Example: $\frac{1"}{2}$ tubing with an $\frac{1"}{8}$ wall

1. Find the diameter of the large circle.

   diameter of large circle $= \frac{1"}{8} + \frac{1"}{2} = \frac{1}{8} + \frac{1}{2} \times \frac{4}{4}$

   $= \frac{1}{8} + \frac{4}{8} = \frac{5"}{8}$

   (to add fractions you must have a common denominator

2. Find the radius of the large circle.

   Recall: radius $= \frac{1}{2} \times$ diameter

   $\therefore$ radius $= \frac{1}{2} \times \frac{5"}{8} = \frac{5"}{16}$

3. Find the radius of the inside circle.

   Recall: radius $= \frac{1}{2} \times$ diameter

   $\therefore$ radius $= \frac{1}{2} \times \frac{1"}{2} = \frac{1"}{4}$

4. Find the area of the tube.

   $$\text{Area} = (\pi \times \frac{5"}{16} \times \frac{5"}{16}) - (\pi \times \frac{1"}{4} \times \frac{1"}{4})$$

   $$\text{Area} = (3.14 \times \frac{25}{256}) - (3.14 \times \frac{1}{16})$$

   $$\text{Area} = \frac{78.5}{256} - \frac{3.14}{16} = \frac{78.5}{256} - \frac{3.14}{16} \times \frac{16}{16} \doteq \frac{78.5 - 50.24}{256}$$

   $$= \frac{28.26}{256} \doteq 0.11 \text{ sq. in.}$$

2.) Stress:

$$\text{Stress} = \frac{\text{Force}}{\text{Area}}$$

Example: 12,000 lb. force and a steel bar whose dimensions are $1" \times \frac{3"}{8}$

1. Find the area of the bar.

   Area = length x width

   $\text{Area} = 1" \times \frac{3"}{8} = \frac{3}{8}$ sq. in.

MATH CONCEPTS cont.

2. Find stress.

$$\text{Stress} = \frac{\text{Force}}{\text{Area}}$$

$$S_t = \frac{12{,}000 \text{ lbs.}}{\frac{3}{8} \text{ sq. in.}} = 12{,}000 \times \frac{8}{3} = \frac{96{,}000 \text{ lbs.}}{3 \text{ sq. in.}} = 32{,}000 \text{ p.s.i.}$$

3) Percent of Elongation:

$$\% \text{ of elongation} = \frac{\text{deformation}}{\text{original length}}$$

Example: 7" steel bar will stretch to $8\frac{3}{8}$"

1. Formula for deformation:

   deformation = stretched length - original length

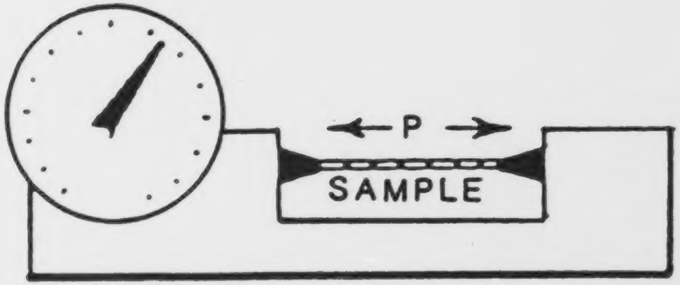
2. Find deformation.

   $$\text{deformation} = 8\frac{3}{8}'' - 7'' = 1\frac{3}{8}''$$

3. Find the percent of elongation.

   $$\% \text{ of elongation} = \frac{1\frac{3}{8}}{7} = \frac{\frac{11}{8}}{7} = \frac{11}{8} \times \frac{1}{7} = \frac{11}{56} = 0.20$$

TENSILE STRENGTH OF STEEL



TENSILE TESTER

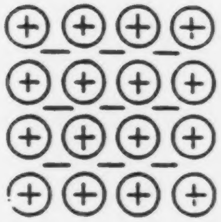
MATH

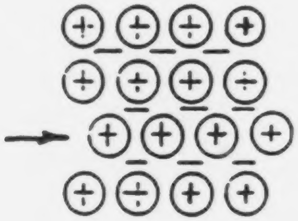
$$\text{STRESS} = \frac{\text{FORCE}}{\text{AREA}} \rightarrow S = \frac{P}{A}$$

$$\text{\% OF ELONGATION} = \frac{\text{DEFORMATION}}{\text{ORIG. LENGTH}} \rightarrow \epsilon\,\text{(epsilon)} = \frac{e}{L}$$

TENSILE STRENGTH OF STEEL

SCIENCE





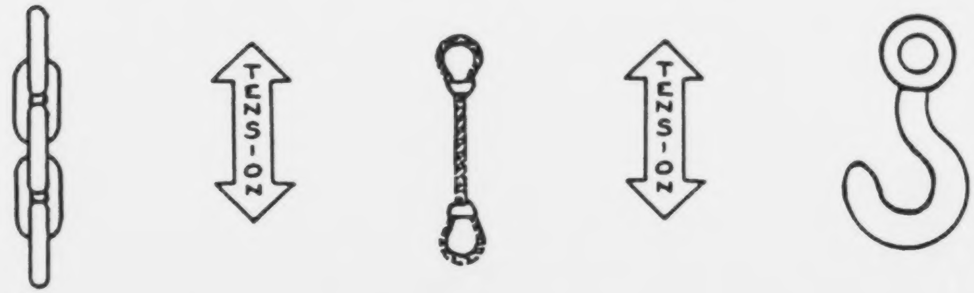
ORDERED LATTICE

HIGH TENSILE STRENGTH

DISORDERED LATTICE

LOW TENSILE STRENGTH

APPLICATIONS

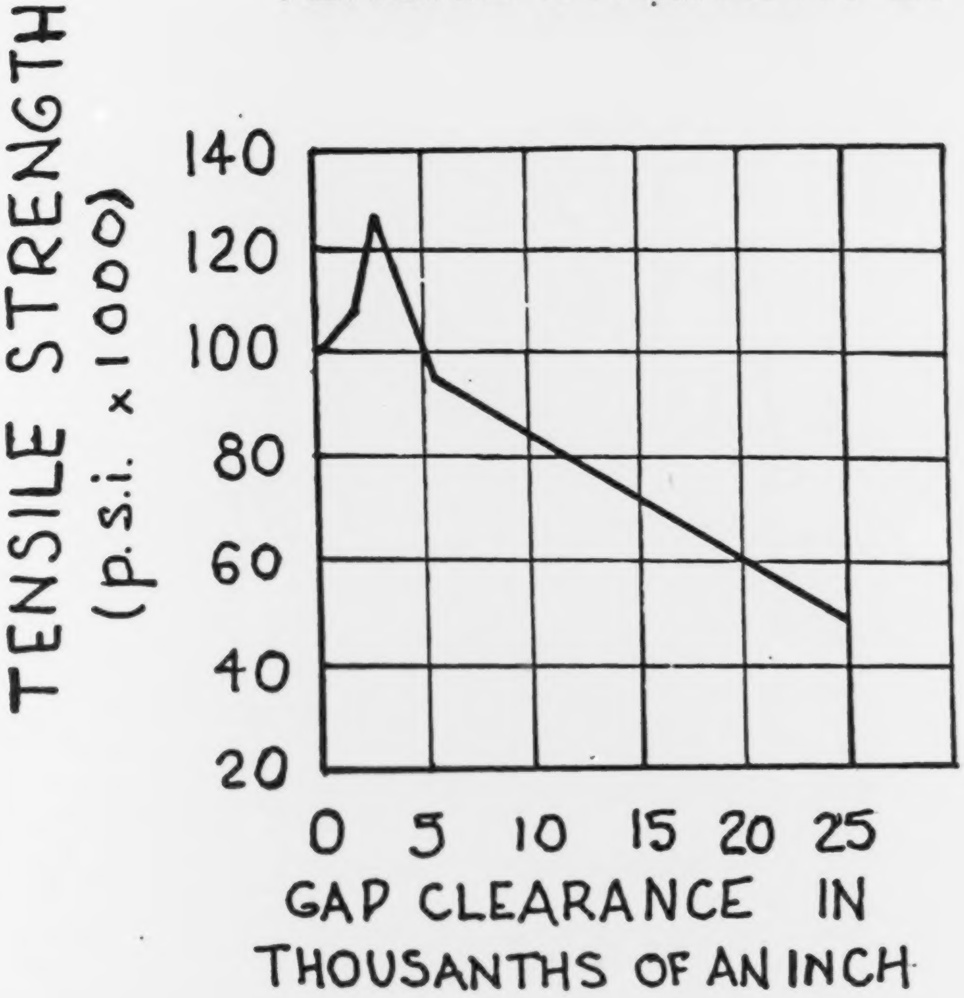


CHAIN

CABLE

FITTINGS

TENSILE STRENGTH OF STEEL



Title: Trusses

Description:

A wood trussed rafter is a framework of wood framing members which form a light, strong, rigid structural unit capable of relatively large clear spans.

Science Concepts:

1. Statics is the science which deals with forces of equilibrium. Graphic statics is the solution of statical problems using geometric diagrams.

2. Equilibrium results when forces whose combined effect produces no motion or change in state of rest.

3. A truss is a framed structure so designed that stresses in the members are capable of holding the external forces in equilibrium.

4. A Force is an action which produces motion, pressure or tension. The net force acting upon a body is equal to the rate of change of the body's linear momentum.

F = Ma here: F = Force
M = Mass
a = acceleration

5. Forces which act upon a system of particles may be divided into two categories:

a. Internal Forces - that the particles within the system exert upon one another.

b. External Forces - that originate outside the system. Stress is an external force.

Stress = Force/Area

6. Weight is a force - W = mg here: W = weight
m = mass
g = 9.8m/s^2

7. The three properties or elements of force are:
a. Magnitude - the magnitude of a force is its number of units of energy.

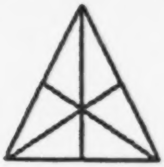
b. Direction - direction in which a force tends to move an object.

c. Line of action - path along which a force acts.

8. Every body of matter has a certain center of gravity (centroid) which is the effective location of the body's mass insofaras external forces are concerned.

MATH CONCEPTS:

1. Centroid is the center of gravity found in all shapes. In a truss, there are many center of gravitys with the structure itself. An example of locating the the centroid shows that it may be done by intersecting the medians of the triangle. Note: A median is a line segment drawn from the midpoint of a side to the opposing vertex.



THE CENTROID IS LOCATED AT THE POINT OF INTERSECTION OF THE THREE LINE SEGMENTS.

2. Angle measure terminology:

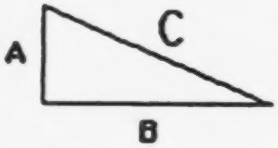
   Acute angle = angle whose measure is less than 90 degrees.
   Right angle = angle whose measure is equal to 90 degrees.
   Obtuse angle = angle whose measure is greater than 90 degrees.

3. Triangle terminology:

   Isoceles triangle = triangle with two equal sides. (truss forms this)
   Right triangle = triangle that contains one right angle.

4. The sum of the interior angles of a triangle is 180 degrees.

5. Pythagorean Theorem Method for finding the missing side of a right triangle:



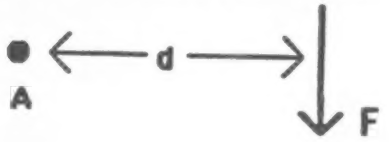
$$C^2 = A^2 + B^2$$

6. Vectors show the magnitude of a force and its direction. The word magnitude refers to the units of energy contained within a force. The direction of a force is the direction in which a force tends to move an object.

7. Resultant Vector (Vector Addition): The sum of two vectors is equal to the sum of the individual components.

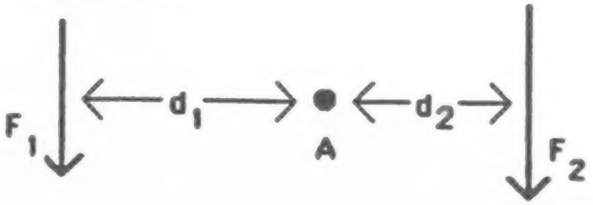
Example: V1 = (a,b) & V2 = (c,d) then V1+V2 = (a+c,b+d)

8. Moment (Torque): Something producing or tending to produce rotation or torsion. A moment is the result of some force acting a perpendicular distance from a point.



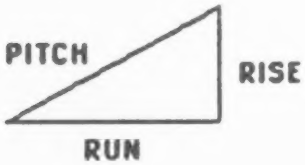
$$M_A = F \times d$$

9. Opposing Forces: Forces acting on the same point in different directions.



$$M_A = (F_1 \times d_1) - (F_2 \times d_2)$$

10. Pitch (Slope): The pitch can be simply defined as rise over run. For example, a common building pitch is 6"/12". Mathematically interpreted this means that the roof rises 6" vertically for every 12" horizontal span. The closer pitch is to zero, the more flat the surface of the roof.



$$\text{PITCH} = \frac{\text{RISE}}{\text{RUN}}$$

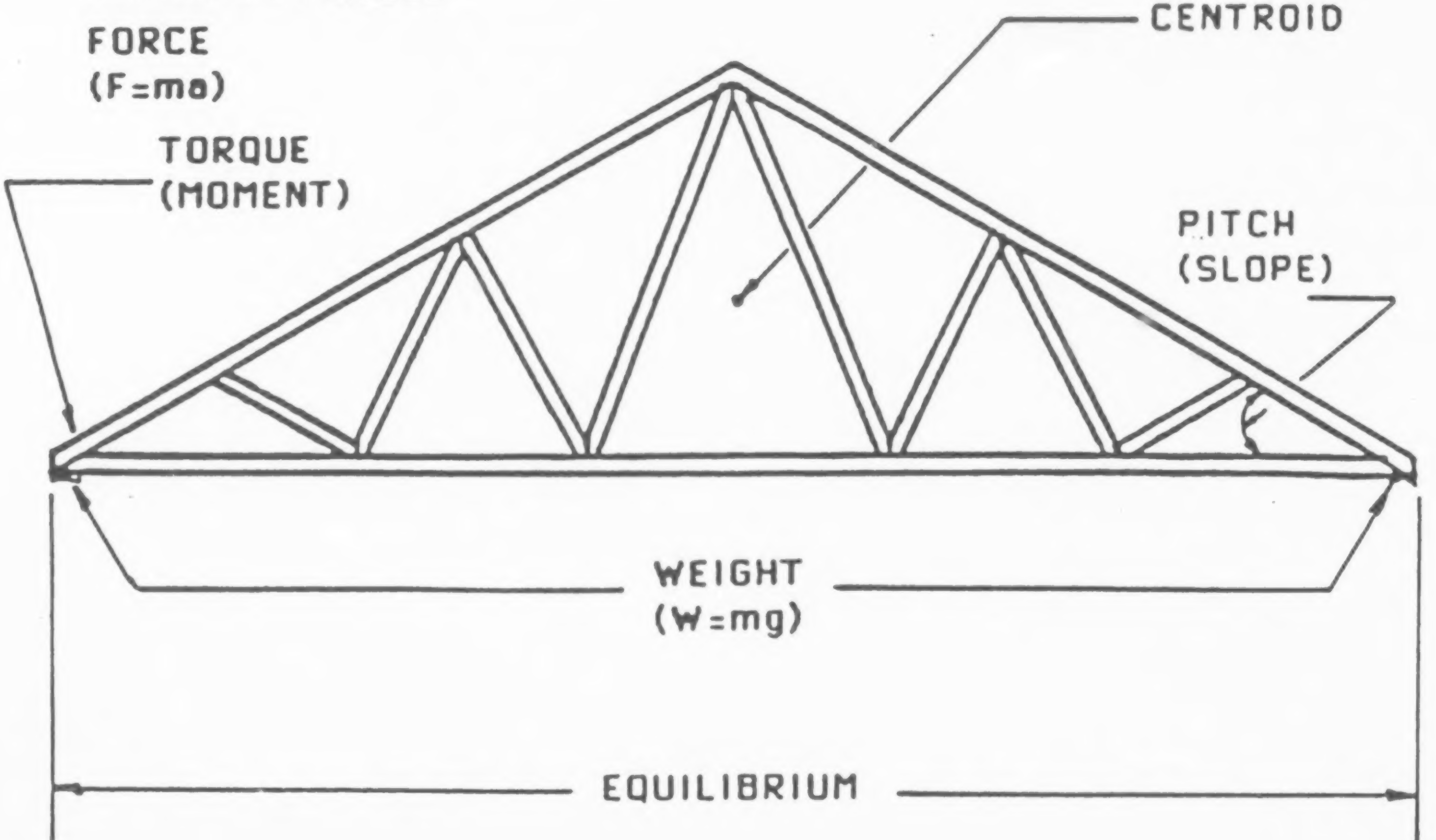
TRUSS DESIGN & CONSTRUCTION

THE "TYPICAL" REPRESENTATIONS OF GENERALIZED CONEPTS ARE LISTED BELOW:

EXTERNAL FORCES

INTERNAL FORCES

FORCE
(F=ma)



TORQUE
(MOMENT)

CENTROID

PITCH
(SLOPE)

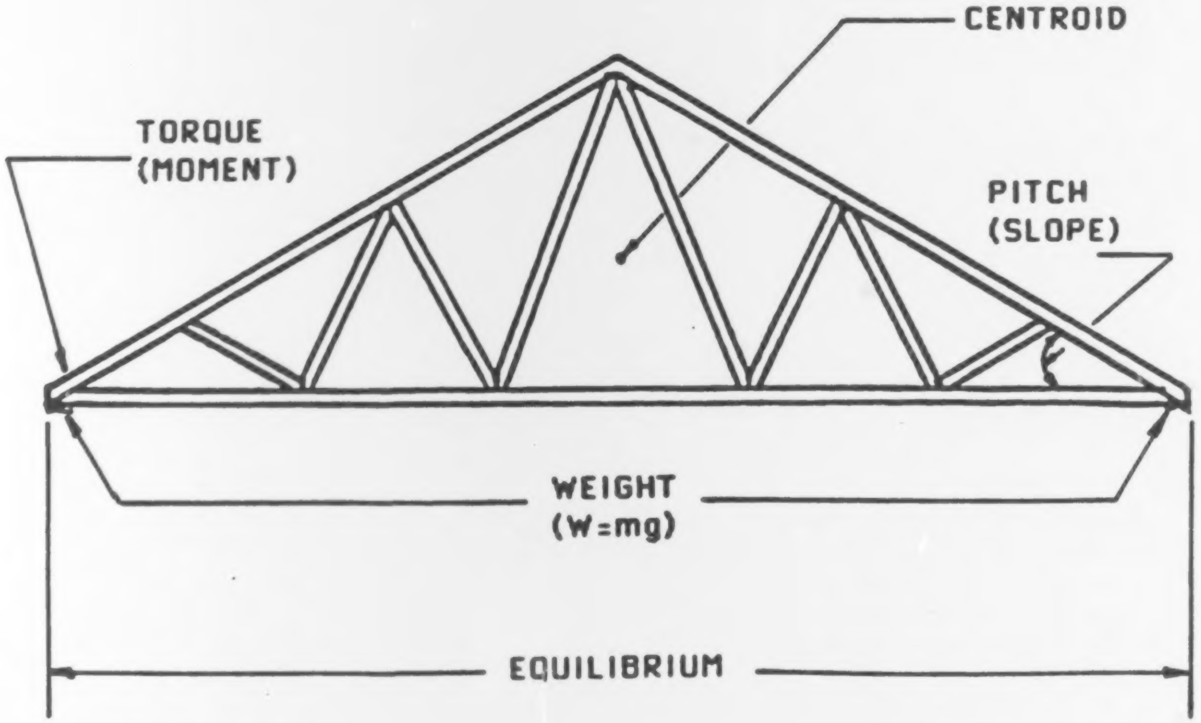
WEIGHT
(W=mg)

EQUILIBRIUM

APPLIED CONCEPTS:

THE "TYPICAL" REPRESENTATIONS OF GENERALIZED CONEPTS ARE LISTED BELOW:

EXTERNAL FORCES
INTERNAL FORCES
FORCE
(F=ma)


CENTROID
TORQUE
(MOMENT)
PITCH
(SLOPE)
WEIGHT
(W=mg)
EQUILIBRIUM

TITLE: WALL INSULATION

CATEGORY: CONSTRUCTION

DESCRIPTION:

All materials resist the transfer of heat in direct proportion to their thicknesses. However, modern construction practices and the weight of materials limit the thicknesses of building materials that may economically be used. For this reason the loss of heat from buildings in winter and the gain of heat in summer are controlled by thermal insulation such as spun glass, foamed glass, vegetable fibers, mineral fibers, and certain foamed plastics. These materials may be pressed into boards, installed as loose blankets or batts, or blown in granular form into walls and ceilings.

SCIENCE CONCEPTS:

1. Energy is the ability to do work or cause change.
2. Examples of some types of energy are heat, light, sound, chemical, and physical.
3. Energy can be converted from one type to another.
4. When light is absorbed by a material, most of the light energy is usually converted to heat energy.
5. Heat may be transferred by conduction, convection, or radiation.
6. Conduction is the transfer of heat from molecule to molecule by direct contact.
7. Convection is the transfer of heat by the movement of molecules in fluids.
8. Radiation is the transfer of heat which does not require a medium.
9. A good insulating material has a large portion of "dead air" space to retard conduction and convection and a shiny surface to reflect radiant energy away.

TITLE: WALL INSULATION

CATEGORY: CONSTRUCTION

MATHEMATICAL CONCEPTS:

1. Heat is measured by Btu (British thermal units).

2. A Btu is the amount of heat required to raise one pound of water one degree Fahrenheit.

3. The rate of heat transfer is expressed as Btuh (British thermal units per hour).

4. All materials conduct heat. The rate at which a material conducts heat is its K factor.

5. The K factor is the number of Btuh that is conducted by one square foot of the material one inch thick with a difference of one degree Fahrenheit on each side.

6. The combination of all of the K factors in a building section is the U factor for that section.

7. The purpose of thermal insulation is to resist the flow of heat. The resistance of a material to the flow of heat is its R value.

8. The R value is the reciprocal of the U factor.
   $R = \frac{1}{U}$

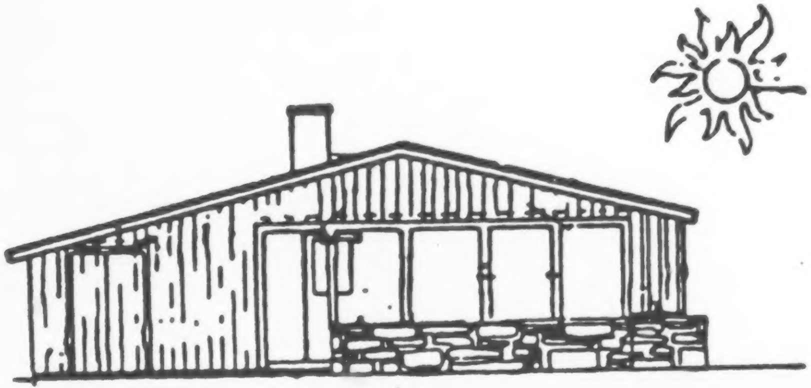
9. The design temperature difference is the difference between the lowest probable outside temperature and the desired inside temperature.

10. The heat transmission load is the amount of heat that is lost through the building materials.

11. The following four steps are used to find the transmission load:

    A. Find the square foot area of each outside section by multiplying its height by its length.
    B. Divide the R value (from table) into the section area to find the heat transmission per degree difference for that section.
    C. Add the transmission load per degree difference for all sections.
    D. Multiply the total transmission load per degree difference by the number of degrees of design temperature. This result will be the total heat transmission load for the building.

WALL INSULATION



SCIENCE CONCEPTS

Energy Conversion

Heat Transfer

Insulation

MATH CONCEPTS

British Thermal Units

Resistance Factor

Surface Area

Heat Transmission Load